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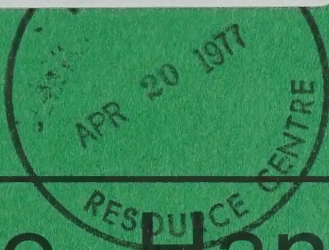
EPS 3-WP-77-3

WASTE HANDLING, DISPOSAL AND RECOVERY IN THE METAL
FINISHING INDUSTRY, 1977.

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Waste Handling, Disposal and Recovery in the Metal Finishing Industry

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Economic and Technical Review
Report EPS 3-WP-77-3

Water Pollution Control Directorate
March 1977

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PROCEEDINGS

TECHNOLOGY TRANSFER SEMINAR

on

WASTE HANDLING, DISPOSAL AND RECOVERY

IN THE METAL FINISHING INDUSTRY

Toronto, Ontario

November 12-13, 1975

Sponsored by

Environmental Protection Service
FISHERIES AND ENVIRONMENT CANADA

Automotive Parts Manufacturers' Association (Canada)

American Electroplaters' Society

Report No. EPS 3-WP-77-3
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PREFACE

The Technology Transfer Seminar "Waste Handling, Disposal and Recovery in the Metal Finishing Industry" was co-sponsored by the Environmental Protection Service, Environment Canada, the Automotive Parts Manufacturers' Association (Canada), and the American Electroplaters' Society. The topics presented and thoroughly discussed related to recycle, disposal and centralized treatment of metal finishing wastes, as well as the current status of government regulations. These proceedings include both the original papers presented by speakers at the seminar and transcripts of the extensive panel discussions which followed the presentations.

Available technologies for water reduction in plating processes and various treatment operations, such as chemical precipitation, ion exchange, distillation and reverse osmosis, were reviewed and the economic and technical feasibility of recycling treated sludges and purified effluents was discussed. Much interest was expressed in the concept of centralized treatment plants, which are operating in Europe and, in particular, in Germany. The design, operation, maintenance and cost data for such plants are outlined along with discussions of sludge disposal problems. The possibility of applying this technology in Canada was discussed in relation to the current government attitudes towards the control of effluents from metal finishing operations.

These proceedings reflect a balanced grouping of inputs from government, metal finishers, and technical experts, and should be of considerable use to anyone concerned with waste discharges from the metal finishing industry.

PREFACE

Le colloque sur l'application des techniques de manutention, d'élimination et de recyclage des rebuts dans l'industrie de finition des métaux a été coparrainé par le Service de la protection de l'environnement (MPE) par l'Association des fabricants de pièces d'automobiles (Canada) et par l'American Electroplaters' Society. Les exposés et les échanges de cette rencontre ont porté sur le recyclage, l'élimination et le traitement centralisé des rebuts de finition ainsi que sur les règlements pertinents actuels; les délibérations sont reproduites ci-après.

Les techniques connues de réduction de l'eau dans les procédés électrolytiques et diverses méthodes de traitement comme la précipitation chimique, l'échange d'ions, la distillation et l'osmose inverse ont fait l'objet d'un examen; les participants ont, en outre, étudié la possibilité de recycler les boues traitées et les effluents purifiés. Les installations de traitement centralisées telles qu'il en existe en Europe, et plus particulièrement en Allemagne, ont suscité un vif intérêt. Les données sur la conception, l'exploitation, l'entretien et les coûts de ces installations apparaissent dans le compte rendu, qui étudie également les problèmes d'élimination des boues. Par ailleurs, le débat a porté sur la possibilité d'appliquer de telles techniques au Canada compte tenu des règlements qu'adoptent actuellement les gouvernements pour surveiller la qualité des effluents des ateliers de finition des métaux.

La participation des gouvernements, des industriels et des experts à ce colloque était bien partagée; le compte rendu en fait foi et il devrait se révéler des plus utiles à tous ceux que préoccupe le traitement des rebuts de l'industrie de finition.

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PROGRESS REPORT ON THE DEVELOPMENT OF NATIONAL EFFLUENT
REQUIREMENTS FOR THE METAL FINISHING INDUSTRY

by

L. Buffa
Water Pollution Control Directorate
Environmental Protection Service
ENVIRONMENT CANADA

Federal Government action to give expression to its environmental concern has taken many forms. These have ranged from establishing a new Department of the Environment, to launching of a major program of new or amended legislation.

As part of this program the Fisheries Act, the oldest "Environmental" Act in Canada, was amended to enable the Federal Government to take measures to regulate specific industrial effluents. The Fisheries Act contains a general provision which states that substances deleterious to fish cannot be deposited in waters where fish live.

The amendments provide the authority to prepare regulations specifying, for a given industry, the quantity of deleterious substances which can be discharged with the effluents. Such quantities may be expressed as the concentrations of the deleterious substances in the final effluent. They may be also expressed in terms of pounds per unit of production. When possible and practical national requirements are expressed in terms of pounds per unit of production.

Any water pollution problem associated with an industrial discharge can be addressed to in two ways. In the absence of regulations for the given industry, test fish can be exposed to the effluent and if they die this will be sufficient evidence to prove the existence, in the effluent, of a substance deleterious to the fish itself. The test, of which I gave you an oversimplified description, is called an acute toxicity test. It can be used in court to prove a violation of the Act.

When Regulations for an industry are in place, they will specify which substances deleterious to fish can be discharged in specified quantity in the effluents of the industry regulated.

Two main features characterize the program now being conducted by EPS in this field. First the objective, which is containment - to keep pollution within the factory fence. Second the strategy used to achieve this objective - which is the use of best practicable technology. Boiled down to its essentials, this means that we do not insist that companies apply a certain technology. We do make sure that the requirements we set can be met, using best practicable technology. We then say to industry - in effect we don't care how you do the job - just that it does get done.

This has been the essence of our approach in the drafting of regulations for, among others, the metal finishing industry.

In 1973, we looked at metal finishing under its broad definition. In this preliminary study we identified more than 7,000 plants in Canada, most of them captive operations. Our first step was to consider control requirements for a specific part of the industry. This was the segment engaged in operations such as chemical and electrolytic finishing of surfaces and cyanide hardening. For help in understanding this industry and in developing a technical base for effluent controls, we looked to the industry itself.

We needed to know who was doing what, and where and how many thousands of pounds of various chemicals were consumed in metal finishing processes. What kind of wastewater control measures - internal and external were already in place? Were the results of such monitoring being recorded and reported to any authority?

We decided then to survey all the companies that could possibly fall within the segment of the industry we intended to regulate first. We drew up a list of questions and sent them to more than 1,000 companies. In a covering letter we explained our commitment to the principle of consultation and we emphasized the importance of an adequate response.

We consulted the companies believed to be active in electroplating, anodizing, cyanide hardening, electroless plating, phosphating, chromating and bright dipping.

Metal finishing operations which are part of larger industrial activities such as steel production, foundry operations and so on were not included in the survey. Effluents requirements for such activities were, at the time the survey was designed, expected to include the captive metal finishing component.

Table 1 shows a summary of questionnaires sent and replies received. More than six hundred replies were received and analysed. In view of the segment of the industry under examination, companies having mechanical, physical or non-metallic processes only were considered not applicable.

Tables 2 and 3 show the subdivision we originally made between chemical and electrolytic processes. This subdivision may very well appear artificial when looking at the industry as a whole. However, it was adopted at an early stage to allow for sub-categorization.

Table 4 shows the questions we asked in connection with each process.

As you can see, an effort was made initially to define a production parameter in view of its possible use in connection with effluent limitations. This means that, for an initial period of approximately one year, we considered effluent requirements expressed in terms of pounds per unit of production, or pounds per square foot finished, for example. This approach was later abandoned as impractical under our conditions.

Tables 5, 6, 7 and 8 contain a summary of some of the results and these should be interesting to many of you. More than two-thirds of the companies replying were captive operations. More than half declared ten or less men employed in the metal finishing operations (Table 5). Approximately two-thirds of the plants are apparently discharging into municipal sewers (Table 6).

TABLE 1 SUMMARY OF QUESTIONNAIRES SENT AND REPLIES RECEIVED

	QUESTIONNAIRES MAILED	REPLIES RECEIVED	APPLICABLE
Newfoundland			
Nova Scotia	15	9	4
New Brunswick			
Quebec	272	150	62
Ontario	572	311	217
Manitoba			
Saskatchewan	165	88	28
Alberta			
British Columbia	64	51	30
TOTAL	1088	609	341

TABLE 2. CHEMICAL PROCESSES

Degreasing	(i) Vapor (ii) Emulsion (iii) Detergent	Phosphating
Pickling		Chromating
De-Rusting		Electroless Copper Plating
Stripping Metal Coatings		Electroless Nickel Plating
Passivating		Bright Dipping
Activating		Hardening
		Other (Specify)

TABLE 3 ELECTROLYTIC PROCESSES

Degreasing	(i) Vapor	Anodizing	(i) Sulphuric
	(ii) Emulsion		(ii) Chromic
	(iii) Detergent	Lead Plating	
Pickling		Copper Plating	(i) Cyanide
Electrocleaning			(ii) Acid
		Nickel Plating	(i) Bright
Etching			(ii) Semi-Bright
Chromium Plating		Brass Plating	
		Gold Plating	
Tin Plating		Silver Plating	
Zinc Plating	(i) Cyanide	Electropolishing	
	(ii) Non Cyanide		
Cadmium Plating		Other (Specify)	

TABLE 4. QUESTIONS ASKED WITH QUESTIONNAIRE

Products Processed Per Day (sq. ft. or lb.)

Maximum Yearly Capacity (sq. ft. or lb.)

Number Of Process Tanks

Capacity Of Process Tanks

Main Chemical Consumed (lb./yr.)

Number Of Dumps Per Year

Metal Anodes Consumption (lb./yr.)

TABLE 5. DISTRIBUTION BY EMPLOYEES

Employees In Metal Finishing	Chemical Only	Electrolytic And Cyanide Hardening	Total	Captive
1 - 10	76	113	189	133
11 - 50	28	80	108	73
Over 50	10	34	44	35
Total	114	227	341	241

TABLE 6. WASTEWATER DISCHARGES

To Municipal Sanitary Sewer	218
Other	86
Not Reported	37

TABLE 7. WASTEWATER CONTROL

	Chemical Only	Electrolytic and CN Hardening
pH Control	21	65
Solids Separation	42	92
CN Ion Control	0	54
Chromium Ion Control	9	55
Other Metals Control	9	50
Total Companies Responding to Survey	114	227

We found some companies already taking steps to control their effluents (Table 7) and a limited number were doing some monitoring, keeping records and advising the authorities (Table 8).

Detailed results of the survey are contained in a report published by the Environmental Protection Service (EPS) entitled "Review of the Canadian Metal Finishing Industry"*.

The consultation between representatives of industries and governments takes place within the structure of a Task Force. Task Force members are, by design, expected to represent federal, provincial and industrial concerns. Ideally, the Task Force agrees on a package of recommendations for effluent control. The recommendations are then analysed by the senior management of the federal Water Pollution Control Directorate and accepted, modified or sent back for further elaboration as the case requires. Discussions within the Task Force are usually open and informal.

While the national survey was underway we began organization of the Task Force by inviting participation in it. Table 9 shows what I consider the ideal membership. What we actually got is shown in Table 10. As it happened, the Automotive Parts Manufacturers' Association was the only one available to make a representation. This group did an excellent job of briefing us, formally or informally as required, from the very beginning of our relationship.

The provinces of Ontario and Quebec, where an estimated 95% of the volume of metal finishing work is done, have representatives on the Task Force. The other provinces are routinely briefed on work that has been done.

As a result of preliminary work conducted prior to the first meeting of the Task Force, we collated into a report the following items: a description of the industry; the results of the survey; and, a review of the options available from water pollution control, ranging from water pollution prevention to effluents treatment. We also incorporated a short review of foreign requirements and a report submitted at my request by the plant pollution sub-committee of the Automotive Parts Association.

*Report EPS 3-WP-75-2

TABLE 8. WASTEWATER MONITORING

<u>Monitoring of:</u>	<u>Chemical</u>	<u>Electrolytic and CN Hardening</u>
pH	25	84
CN	1	40
Metals	11	46
Suspended Solids	10	40
Record Keeping	25	81
Authorities Advised	13	49
Total Companies Responding to Survey	114	227

TABLE 9. TASK FORCE COMPOSITION

- Environmental Protection Service	}	Department of the Environment
- Fisheries Service		
- Industry		
- Provincial Agencies		

TABLE 10. ACTUAL MEMBERSHIP OF THE TASK FORCE FOR THE
DEVELOPMENT OF NATIONAL EFFLUENT REQUIREMENTS

- Environmental Protection Service
- Fisheries Service
- Automotive Parts Manufacturers Association
- Provinces of Ontario and Quebec

The Task Force examined this package, agreed on the content and set out to discuss possible solutions, that is, control requirements. Let us look at this point more closely.

We know that the main wastewater constituents are heavy metals, cyanides and other inorganic and organic substances. They originate from three main sources: dumps, spillages and leaks, and rinse water.

Dumps result from the disposal of spent solutions and sludges generated by the normal operation of a metal finishing plant. They may contain up to 200,000 milligrams per litre of contaminants. Dumping is usually an off-shift operation. Where regeneration is not practical, dumps can be segregated and treated or sent to a disposal facility.

Spillages and leaks, resulting from overflows, accidents, etc., can be contained and recycled, treated or sent to a disposal facility.

It is estimated that approximately 70% of the chemicals consumed by the industry is lost through dumps, spillages and leaks. It is an obvious conclusion that, in order to match the sources of water pollution, the dumping of sludges and concentrated solutions should be explicitly prohibited. It is also obvious that metal finishing plants should apply good housekeeping procedures to contain spillages and leaks.

It appears, from the work done to date, that the rinse water contains the balance of chemicals and up to 8% of the metal anodes consumed. The rinse water is normally discharged with the plant effluent. For this reason each control parameter in the final effluent should be limited by specifying its maximum concentration.

Agreement was then reached in matching the requirements to the sources of water pollution. It seemed that it might not be possible to express some of these requirements under the Fisheries Act in its present form, so it was agreed that a combination of Regulations/Guidelines and Code of Practice might be the best instrument with which to contain water pollution at the factory fence.

I can foresee the national requirements for the metal finishing industry developing along the following lines:

1. Explicitly prohibit dumping procedures.
2. Encourage good housekeeping practices to contain leaks, spillages and accidental losses.
3. Limit the concentration of certain control parameters in the final effluent.
4. Provide for adequate reporting procedures to ensure that the requirements are met.

I should, at this point, mention some of the aspects and difficulties we have met in this regulation development process.

One aspect, a major one, is technical - what is best practicable technology for the metal finishing industry. The Task Force agreed that the application of chemical treatment is part of best practicable technology as it applies to this industry. In fact, chemical treatment appears to be the only technology applicable to all metal finishing effluents. The following steps can be considered part of Best Practicable Technology (BPT) for the development of control requirements: segregation and destruction of oxidizable cyanide; segregation and reduction of hexavalent chromium; precipitation of metals; and, settling, separation and disposal of sludges.

After the application of BPT, metals and other contaminants in the final effluent are expected to be in the order of fractions of milligrams per litre and below or at the levels shown in Table 11.

These values have been subjectively derived from documentation reflecting several years of experience in wastewater treatment in the United States and Germany.*

We expect other metals to co-precipitate during neutralization. Additional stream segregation and separate treatment can produce effluents with concentrations of any particular dissolved metal lower than the values shown. Filtration of the final effluent can reduce

* "Standard Values for Wastewater Purification Procedures"
Normalwerte für Abwasser Reinigungungsverfahren (1970)

"Effluent Limitation Guidance for the Refuse Act Program
Metal Finishing Industry", September (1972)

TABLE 11. EXPECTED LEVELS OF CONTAMINANTS IN FINAL EFFLUENT
AFTER CHEMICAL TREATMENT

pH	6 - 9.5	
TSS	20 - 25 mg/l	
	Total (dissolved and undissolved)	Dissolved
Cd	1.5 mg/l	0.2 mg/l
Cr ^{vi}	0.5 mg/l	0.1 mg/l
Cr ^{tot}	1.0 mg/l	0.5 mg/l
Cu	1.0 mg/l	0.5 mg/l
Ni	2.0 mg/l	1.0 mg/l
Pb	1.5 mg/l	0.5 mg/l
Zn	2.0 mg/l	1.0 mg/l
Fe	2.0 mg/l	1.0 mg/l
CN Oxidizable	0.1 mg/l	0.1 mg/l
CN Total	1.0 mg/l	1.0 mg/l

TABLE 12. METAL FINISHING PLANTS DISCHARGING
TO MUNICIPAL SEWERS

Atlantic Provinces	75%
Quebec	60%
Ontario	70%
Manitoba, Saskatchewan, Alberta	45%
British Columbia	50%

undissolved metal levels to practically nil. Under special circumstances the values shown may not be met. However, it is felt that such instances should be analysed on a case by case basis.

In general, chemical treatment lends itself to the application of additional methods or steps, when required, to further improve the quality of the effluent before discharge. I expect the final values in the requirements to be close to those in Table 11.

Another aspect, or difficulty, is represented by the requirements for plants discharging into municipal sewers. From the survey, it is estimated that metal finishing plants discharge wastewaters to municipal sewers in the percentages shown in Table 12.

The percentages of discharges to receiving waters would considerably increase if the number of municipal treatment plants in existence, and/or the effectiveness of these plants, is taken into consideration. It is obvious that the only difference between direct discharges to receiving waters and discharges to sewers not provided with treatment is the ownership and the jurisdiction over the pipe leading to the receiving waters.

Given the percentage of companies discharging to municipal sewers, and the relative effectiveness of the primary and secondary treatments already in place, it is clear that an effective control of metal finishing waste must include requirements for discharges to municipal sewer systems:

1. To administratively ignore such discharges. This option is not considered.
2. To require individual companies to provide evidence that their effluent is receiving equivalent treatment before discharge to receiving waters, and on this basis to authorize higher numerical limits leaving the plant. Where off-site or municipal treatment is not totally equivalent, the company would be required to provide complementary treatment as required to ensure equivalence with BPT.

3. To issue a table of pre-treatment standards for each control parameter which would apply anywhere in Canada prior to off-site discharge regardless of the off-site treatment capability.

Concern has been expressed over the practicability of enforcement of the federal requirements in the context of existing by-laws. Concern has also been expressed by industry over equity as it relates to different degree of enforcement of by-laws by different municipalities.

All I can say at this point is that the various options and concerns are under active consideration.

Another aspect, a very important one, is the cost of complying with effluent requirements. Because of the variety of processes and conditions within the industry, an accurate analysis of capital and operating costs is difficult. We selected more than 70 companies, all jobbers, for which we had, in addition to survey information, some financial data such as net annual sales. Captive operations were not included because meaningful sales volumes were not available. It was also felt that captive operations could either afford treatment facilities or had the option of subcontracting their metal finishing work.

Our estimate of capital and operating costs for each company within the group is shown in Figure 1. Because of a lack of detailed information on each individual company, costs are indicated as a range.

In general, the cost of applying Best Practicable Technology is estimated to be from \$15,000 to \$100,000 or more, depending upon size and complexity of processes. We estimated smaller plants within the \$15,000 and \$40,000 range. Operating costs are estimated from \$9,000 to \$75,000 per year, depending upon size and complexity. The estimates do not include additional costs for land and building for wastewater treatment, dewatering and disposal of sludges.

The same costs were also plotted versus the number of employees in metal finishing (Figure 2).

Figure 3 shows the operating costs from another point of view, as percentage of net sales.

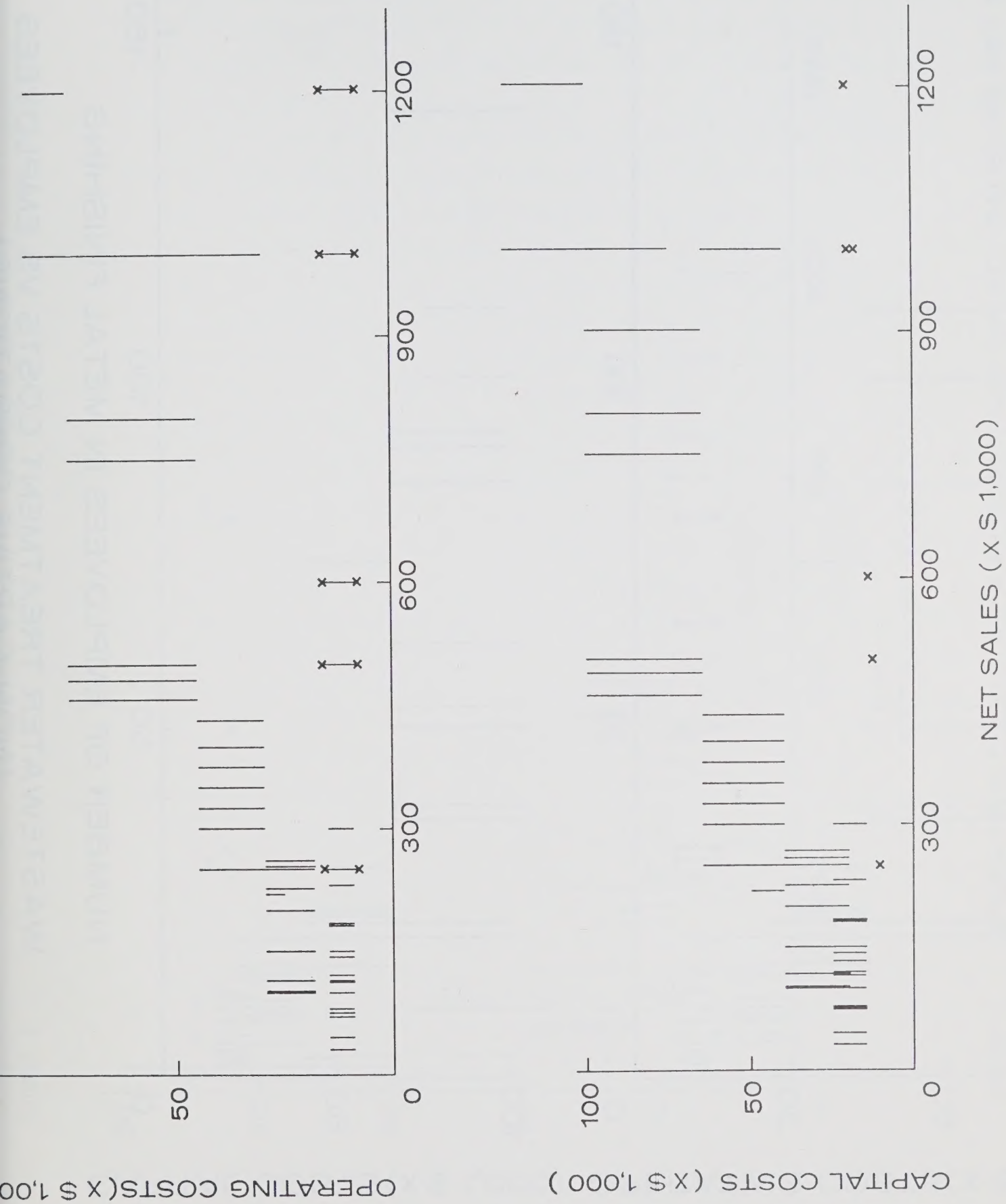


FIGURE 1. WASTEWATER TREATMENT COSTS VS NET SALES
(NON-CAPTIVE OPERATIONS)

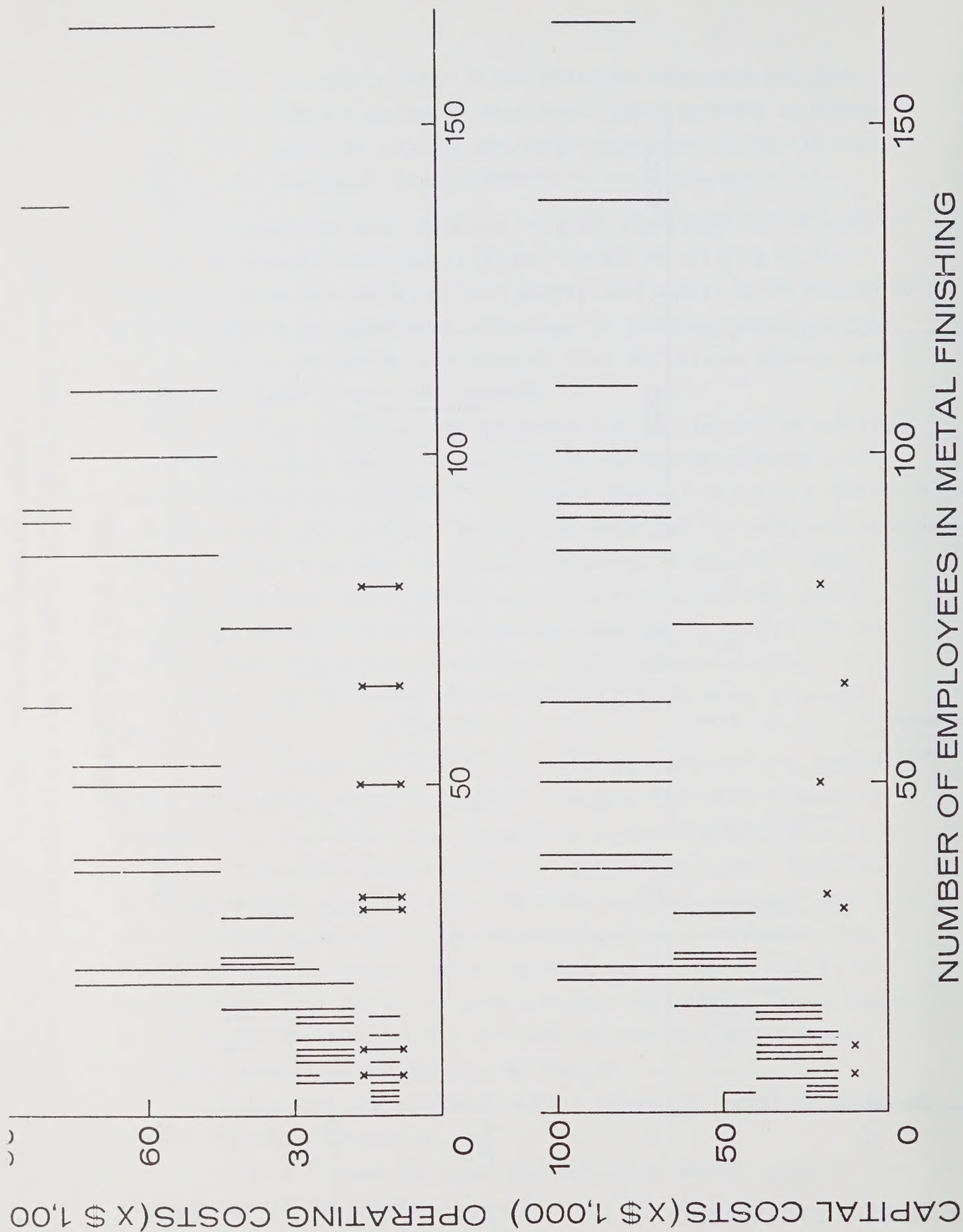


FIGURE 2.

WASTEWATER TREATMENT COSTS VS EMPLOYEES
(NON-CAPTIVE OPERATIONS)

OPERATING COSTS AS A PERCENTAGE OF NET SALES

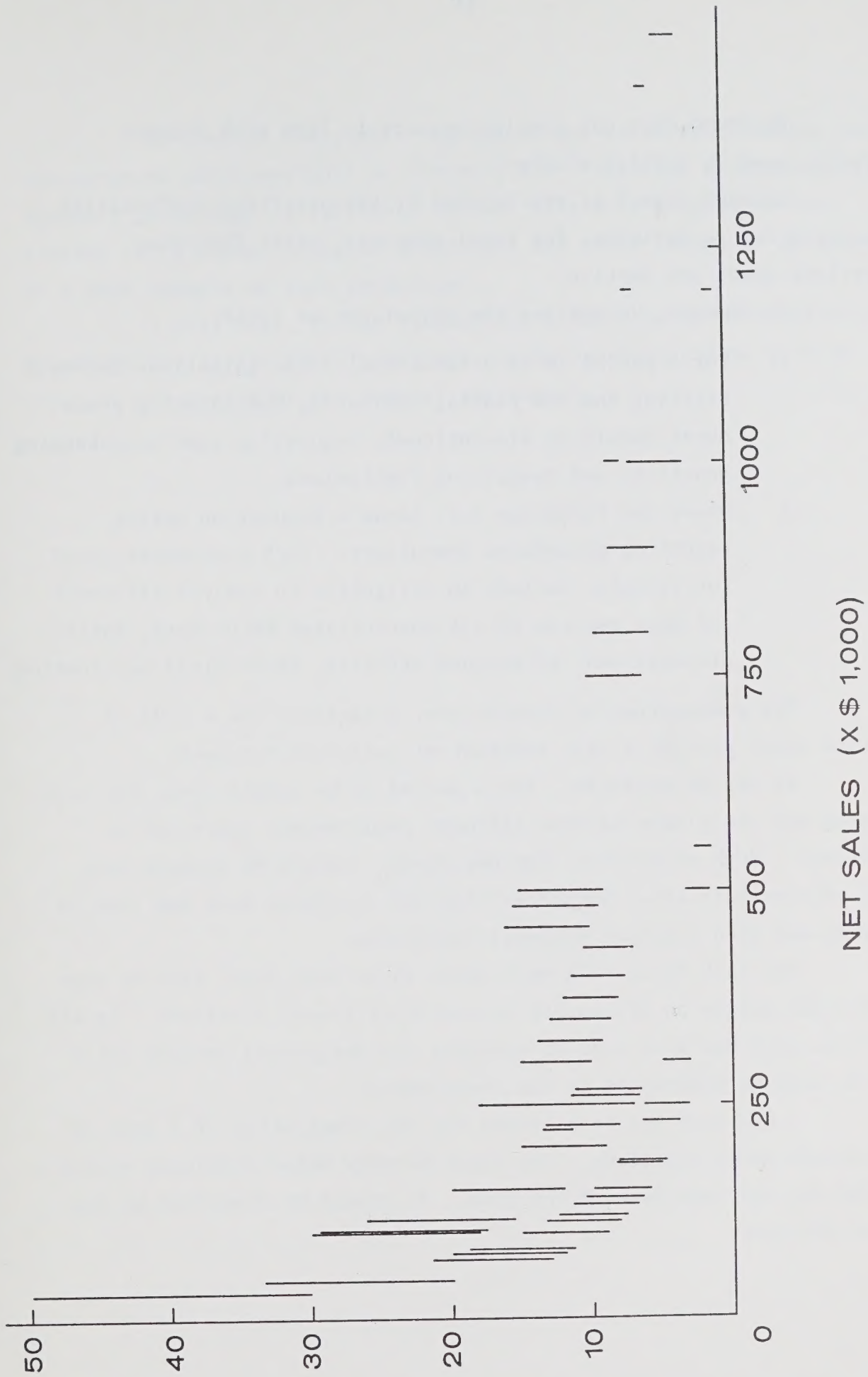


FIGURE 3. OPERATING COSTS AS A PERCENTAGE OF NET SALES VS NET SALES
(NON-CAPTIVE OPERATIONS)

We found that our conclusions are in line with figures currently used in similar studies.

Another aspect is represented by the practical difficulties that may arise in defining, for legal purposes, metal finishing operations which are captive.

In summary, to achieve the objectives we could:

1. For a period to be established, issue guidelines for both existing and new plants, indicating that dumping procedures should be discontinued, requesting good housekeeping practices and specifying limitations.
2. Under the Fisheries Act, issue a Regulation making reporting procedures compulsory. Such procedures could for example, include an obligation to analyze effluents and keep records of all concentrated baths used, their disposal and, if shipped off-site, their final destination.

The combination of regulations, guidelines and a code of practice would provide a very substantial pollution rollback.

It may be necessary, for a period to be established, for both existing and new plants to have effluent requirements expressed as objectives. Such objectives, for new plants, should be changed into legal requirements after municipalities and provinces have had time to consider and plan adequate disposal facilities.

The Task Force will meet again early next year, when we hope to have our policy on discharges to municipal sewers finalized. In the meantime, work has been done on defining the analytical methods which will be used as references in the requirements.

A contract has been issued for the compilation of a code of good housekeeping practices. The input of many metal finishing plants will be an important part of the code. It should be finalized by the end of the year.

We realize that, once segregated and contained, sludges and concentrated solutions must be disposed of. Practical treatment and disposal technology is available abroad. The main purpose of this seminar is to expose Canadian industries and other levels of government to a good example of such technology.

I feel that, in the future, the establishment of centralized treatment facilities for sludges and concentrated solutions will be strongly encouraged by the federal government.

EFFECTIVENESS OF MUNICIPAL TREATMENT PLANTS
IN THE REMOVAL OF METAL FINISHING WASTE COMPONENTS

by

R.A. Abbott
Pollution Control Branch
Ontario Ministry of the Environment

INTRODUCTION

There is a considerable body of literature on the effects of metal finishing wastes, primarily metals and cyanides, on municipal sewerage systems. The purpose of this review is to consolidate available information on the effectiveness of municipal sewage treatment plants in the removal of metal finishing wastes.

There are three principal factors which influence the effectiveness of municipal treatment plants in removing wastes from metal finishing effluents. These are:

1. The characteristics of the metal finishing effluent
2. The interactions between the metal finishing effluent and municipal sewage
3. The type of municipal sewage treatment process.

These factors will be reviewed in the context of their impact on metal finishing waste removal in municipal sewerage systems.

METAL FINISHING WASTE CHARACTERISTICS

Metal finishing wastes are mainly inorganic in nature. They may contain inorganic dissolved solids in the form of alkali metal salts together with heavy metal salts, cyanides, phosphates, sulphates and chromates. In addition, certain metal finishing wastes may contain organic matter either in the form of oils and greases removed from metal parts in cleaning operations or as trace organic constituents of plating and cleaning solution rinses and dumps.

It is difficult to generalize on typical levels of contamination in effluent from metal finishing plants since this very much depends on the type of plant, the type of metal finishing equipment, the production volume and the degree, if any, to which wastes are subject to treatment.

The following general ranges of concentration for the common metal finishing waste parameters are probably typical of untreated metal finishing wastes:

Copper	3-5 ppm
Chromium	5-10 ppm
Zinc	3-5 ppm
Nickel	5-10 ppm
pH range	4-10
Cyanide	1-5 ppm
Suspended solids	10-50 ppm

These typical values do not reflect upset conditions, batch dumps of cleaners and acids or the degree of control that can be achieved in a well operated metal finishing plant which maximizes control and recovery of chemical losses and practices some form of waste treatment.

The organic waste constituents such as oil and grease and oxygen demanding material are most commonly encountered when alkali cleaners are dumped. These do not show up in routine analysis.

Suffice to say that this is the approximate character of wastes which may be discharged to municipal sewerage systems; with the understanding that these contaminant levels may be reduced by waste treatment facilities at the metal finishing plant or may increase substantially during batch dumping of spent solutions.

MUNICIPAL SEWAGE TREATMENT PROCESSES

Municipal sewage treatment processes may be subdivided into four general categories:

1. None
2. Primary sedimentation plants

3. Secondary biological treatment plants
4. Any combination of (2) or (3) with chemical addition for phosphorus removal.

Typical examples of primary and secondary treatment plants are illustrated in Figures 1, 2 and 3. There is a great variety in the type of secondary biological treatment plant likely to be encountered and these range from simple waste stabilization lagoons through aerated lagoons to extended aeration plants. The conventional activated sludge plant differs from these variants in that facilities for the digestion of accumulated activated sludge and subsequent disposal of the digested sludge are necessary.

Conventional activated sludge plants are common to many municipalities in Ontario, although there are exceptions. It should be noted that there appears to be some variation in the type of sewage treatment process which is commonly applied in various regions across Canada so that Ontario experience in this field may not be applicable to all situations in Canada where metal finishing wastes are discharged to municipal sewers.

INTERACTIONS BETWEEN METAL FINISHING EFFLUENTS AND MUNICIPAL SEWAGE

The interactions between metal finishing wastes and municipal sewage dictate the form in which individual waste constituents are received at the municipal treatment plant and to a marked degree influence the extent to which they are removed by the treatment process.

Dissolved metals tend to be precipitated by interaction with municipal sewage. The precipitation of metals by sewage has been reported by S.H. Jenkins, D.G. Keight, J.S. Cooper et al of the Birmingham Tame and Rea District Drainage Board, Birmingham, England. In experiments conducted on Birmingham sewage, soluble copper and nickel were 50 per cent precipitated at dosages up to 100 ppm. Soluble salts of zinc were precipitated by neutral sewage up to 60 per cent at 100 ppm and 80 per cent at 10 ppm. The precipitation of chromates was found to be variable, probably because it is necessary to reduce the chromate to trivalent chromium before precipitation can occur. This reduction would likely

PRIMARY TREATMENT

Primary treatment is mechanical in nature. Settling tanks are used to remove the settleable solids, floating scum and grease from the waste water. This form of treatment is used only when it will meet the water quality requirements of the receiving body.

Settling tanks (clarifiers), equipped with sludge and scum removal mechanisms, provide a detention period of approximately two hours for the incoming wastewater. This detention period allows the waste particles to settle to the bottom of the tanks, from where it is removed by

pumps for conditioning prior to disposal. The sludge removed is pumped to a digester or other treatment facility, where it is processed or dewatered before final disposal.

Primary treatment usually precedes biological treatment, which is carried out in secondary plants.

To summarize: Primary treatment removes the heavier particles, scum and grease from the wastewater. The effluent produced is of a lower standard of quality than is achieved in complete treatment. The amount of solids removed ranges from 40 to 60 per cent.

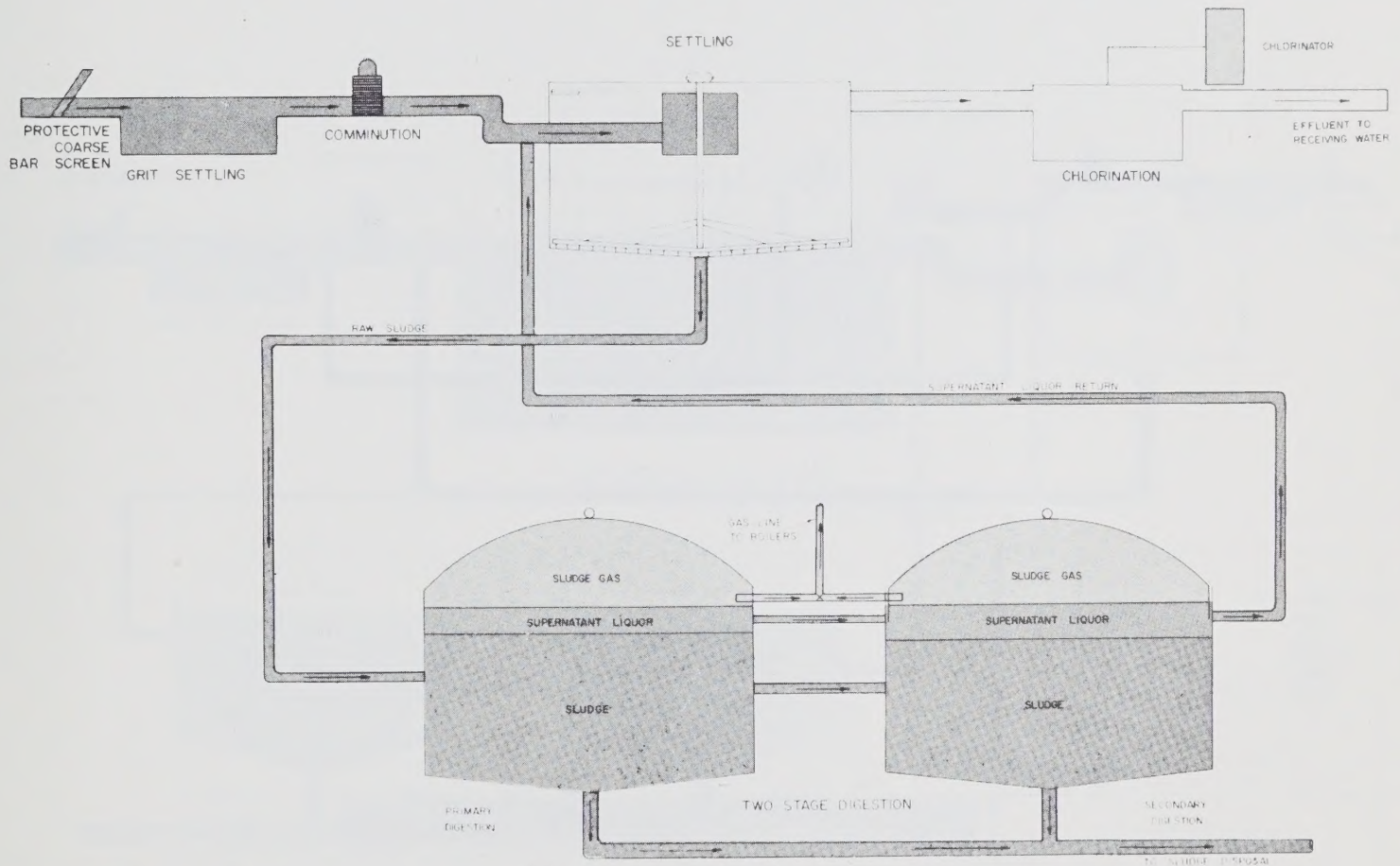


FIGURE 1.

ACTIVATED SLUDGE TREATMENT

The activated sludge process is a method of complete biological treatment which produces a high quality effluent.

This is a secondary process, usually carried out following primary treatment. It removes the finely divided, suspended and dissolved materials remaining in the wastewater.

Biological communities of micro-organisms are developed and maintained in aeration tanks where they are supplied with a plentiful supply of oxygen. The air supply can be provided by compressed air, which is piped directly into the tanks, or by means of mechanical agitators, which revolve and disperse the liquid surface to effect transfer of atmospheric oxygen into the tank's contents. Besides providing dissolved oxygen for the micro-organisms, the air, or agitation, also produces a roll in the tank and prevents settling of solids.

As the organic impurities are assimilated by the micro-organisms, the resulting sludge formation is light and

flocculent and can readily be settled. This sludge is the vehicle upon which the bacteria grow and provides the means for maintaining the process. This sludge floc is referred to as activated sludge because of the biological communities growing in and upon it.

Final settling tanks provide the means for removing and reclaiming this sludge floc. As the effluent from the aeration tanks passes through these settling tanks, the settling sludge floc is removed and returned to the process by means of pumps or air lifts and is discharged into the aeration tanks again, along with the effluent flowing from the primary settling tanks.

To summarize: Air is supplied to the micro-organisms, which in turn oxidize the finely divided, suspended and dissolved organic materials in the wastewater. This provides a high degree of purification and a clear effluent. The amount of solids removed ranges from 90 to 95 per cent.

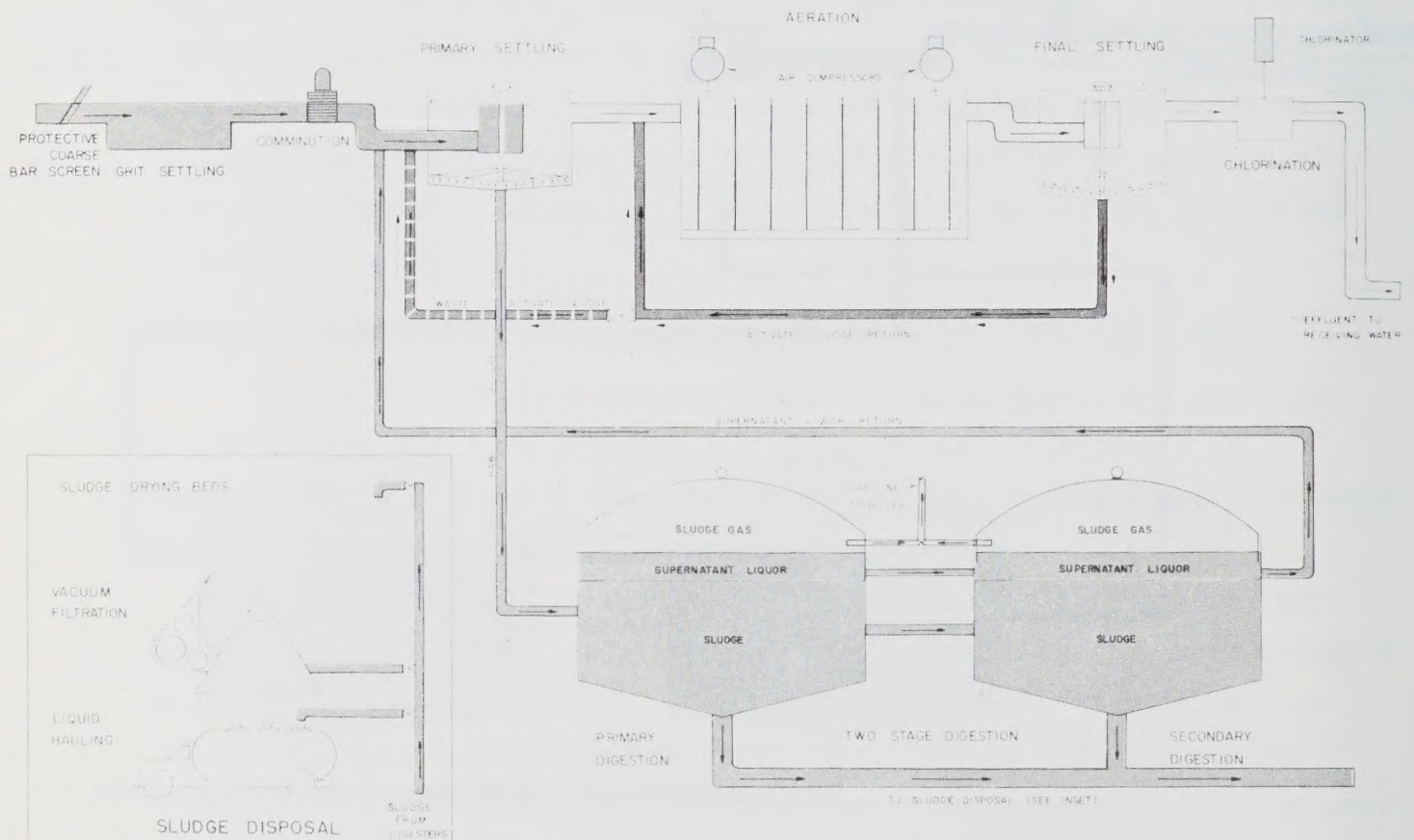


FIGURE 2.

EXTENDED AERATION TREATMENT

The extended aeration process is another method of biological treatment that produces a high quality effluent.

This process is identical to the activated sludge process in its biological application but has no primary settling, and the solids contained in the wastewater are oxidized through an extended aeration period.

Biological communities of micro-organisms are developed and maintained in aeration tanks where they are supplied with a plentiful supply of oxygen. The air supply can be provided by compressed air, which is piped directly into the tank, or by means of mechanical agitators, which revolve and disperse the liquid surface to effect transfer of atmospheric oxygen into the tank's contents. Besides providing dissolved oxygen for the micro-organisms, the air, or agitation, also produces a roll in the tank and prevents settling of solids.

As the organic impurities are assimilated by the micro-organisms, the resulting flocculent sludge can readily be settled. This sludge is the vehicle upon which the bacteria grow and provides the means for maintaining the process. This sludge is referred to as activated sludge because of the biological communities growing in and upon it.

Final settling tanks remove and reclaim this sludge floc. As the effluent from the aeration tanks passes through these settling tanks, the settled sludge is removed and returned to the aeration section by means of pumps or air lifts to be mixed with the incoming sewage.

The small amount of inert and oxidized matter remaining after a period of time is periodically removed to a holding tank or sludge drying bed for final disposal.

To summarize: Air is supplied to the micro-organisms, which in turn oxidize the organic materials in the wastewater. The amount of solids removed ranges from 90 to 95 per cent.

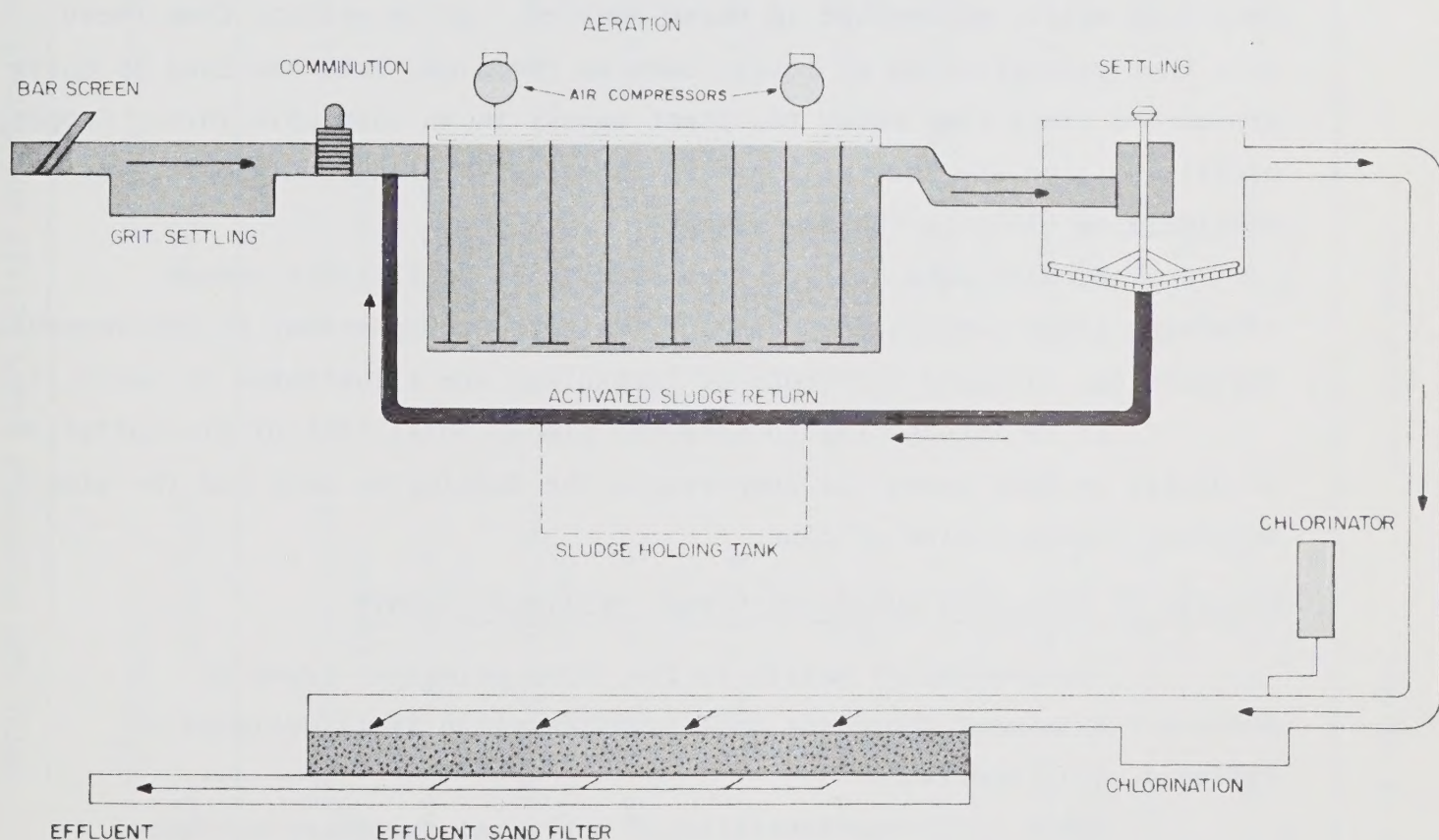


FIGURE 3.

result from interaction between the chromate and organic matter in the sewage. The organic strength of the sewage as measured by BOD or COD, and hence its oxidation reduction potential, and pH probably influence the degree to which chromates are reduced to trivalent chromium. At the levels normally encountered in municipal sewage, chromium is usually present as the trivalent form.

The degree to which interaction between metal finishing wastes and municipal sewage has occurred is best illustrated by some typical examples.

Studies were conducted at the Burlington Skyway Sewage Treatment Plant by Barry G. Oliver and Ernest G. Cosgrove in the summer of 1973 on eight-hour composite samples of raw sewage, primary effluent and final effluent.

Table I illustrates the range of concentrations of total and dissolved metals determined in these samples. It is evident from these data that precipitation of metals such as chromium, iron and lead is quite pronounced since they enter the plant mainly in an insoluble form. Copper, nickel and zinc are less well precipitated, with nickel only partially precipitated (33%) in the raw sewage.

Similar data derived from studies at an Illinois sewage treatment plant conducted by James W. Patterson, Department of Environmental Engineering, Illinois Institute of Technology are illustrated in Table II.

It is interesting to note the almost total lack of precipitation of nickel in this sewage as compared to the Burlington data and the almost complete precipitation of zinc.

REMOVAL OF METALS IN MUNICIPAL SEWAGE TREATMENT PLANTS

The removal of metals in the three principal types of municipal treatment processes under consideration is illustrated in Tables I, III, and IV.

Table I is representative of a typical secondary activated sludge plant in terms of influent and effluent concentrations of metals.

TABLE I

TOTAL AND DISSOLVED HEAVY METALS CONCENTRATIONS OF 8-HOUR COMPOSITE SAMPLES

METAL	RAW SEWAGE		PRIMARY EFFLUENT		FINAL EFFLUENT	
	Total	Dissolved	Total	Dissolved	Total	Dissolved
Cd	0.003-0.02 ^a (0.006)	<0.001-0.002 (<0.001)	0.002-0.01 (0.003)	<0.001-0.002 (0.001)	<0.001-0.005 (0.001)	<0.001-0.001 (<0.001)
Cr	0.01-1.64 (0.29)	<0.01-0.32 (0.02)	0.03-0.80 (0.13)	<0.01-0.14 (0.02)	<0.02-0.68 (0.06)	<0.01-0.02 (0.01)
Co	<0.001-0.05 (0.002)	<0.001-0.001 (0.001)	<0.001-0.001 (0.001)	<0.001-0.001 (0.001)	<0.001-0.001 (0.001)	<0.001-0.001 (0.001)
Cu	0.06-0.98 (0.31)	<0.01-0.72 (0.17)	0.04-0.66 (0.21)	<0.01-0.56 (0.16)	0.01-0.22 (0.08)	<0.01-0.16 (0.07)
Fe	0.5-3.9 (1.54)	<0.05-0.8 (0.15)	0.3-2.4 (0.82)	<0.05-0.3 (0.12)	0.1-1.2 (0.36)	<0.05-0.2 (0.08)
Pb	0.04-1.16 (0.23)	0.007-0.02 (0.012)	0.01-0.49 (0.09)	0.007-0.017 (0.012)	0.001-0.05 (0.015)	<0.001-0.014 (0.006)
Mn	0.04-0.16 (0.06)	0.02-0.1 (0.03)	0.02-0.1 (0.04)	0.02-0.09 (0.03)	0.02-0.07 (0.04)	0.01-0.04 (0.03)
Hg	<0.001-0.020 (0.007)	<0.00005-0.002 (0.0006)	<0.001-0.009 (0.003)	<0.00005-0.001 (0.00003)	<0.001-0.001 (<0.001)	<0.00005-0.0001 (<0.00005)
Ni	<0.03-1.89 (0.33)	<0.03-1.62 (0.22)	<0.03-1.6 (0.28)	<0.03-1.35 (0.22)	<0.03-1.72 (.27)	<0.03-0.58 (0.22)
Zn	0.23-25.99 (2.40)	0.07-4.27 (0.57)	0.23-8.94 (1.13)	0.13-3.4 (0.58)	0.16-2.41 (0.56)	0.06-1.75 (0.40)

a: Range of Values

b: Mean Value

TABLE II

PHASE DISTRIBUTION OF METALS
IN RAW SEWAGE

<u>Metal</u>	<u>Range mg/l</u>	<u>Average Percent Distribution</u>	
		<u>Soluble</u>	<u>Insoluble</u>
Cadmium	0.28- 1.80	33	67
Copper	0.13- 1.76	32	68
Nickel	1.6 -17.1	92	8
Lead	2.4 - 9.8	1.3	98.7
Zinc	0.1 - 9.0	10	90

TABLE III

THE EFFICIENCY OF HEAVY METAL REMOVAL BY A CONVENTIONAL
ACTIVATED SLUDGE TREATMENT PLANT

<u>Metal</u>	<u>3 Day Study % Removal</u>			<u>4 Week Study % Removal</u>		
	by Primary	by Secondary	by Overall Process	by Primary	by Secondary	by Overall Process
Cd	56	50	78	60	50	80
Cr	60	65	86	55	54	79
Co	**	**	**	**	**	**
Cu	30	59	71	33	60	73
Fe	36	59	74	49	55	77
Pb	60	78	91	66	79	93
Mn	32	9	38	33	6	37
Hg	60	< 50	< 80	60	< 62	< 85
Ni	19	> 1	18	15	1	16
Zn	68	31	78	54	50	77

** Cobalt levels were too low to determine removal.

TABLE IV

METALS IN MUNICIPAL SEWERAGE SYSTEMS
INFLUENT AND EFFLUENT CONCENTRATIONS mg/l

Plant Location	Type of Plant	Flow	Date	Sample	Chromium Total	Zinc Total	Copper Total	Nickel Total	Lead Total	Cadmium Total
Chatham	A.S.	4.0 mgd	3.3.70	Influent	1.5	0.80	0.3	4.2	0	0.05
				Effluent	0	0.07	0.01	2.0	0	0.05
				% Removal	100	91	97	52	0	-
Kitchener	A.S.	10.6 mgd	10.2.70	Influent	3.0	0.48	0	0.48	0.16	0
				Effluent	0.4	0.07	0	0.20	0	0
				% Removal	87	85	0	58	100	0
Stratford	A.S.	4.4 mgd	24.2.70	Influent	0.2	0.2	0.29	0.40	0	0
				Effluent	0	0.03	0	0	0	0
				% Removal	100	85	100	100	0	0
Windsor	Pr.	13.1 mgd	8.12.70	Influent	0.56	1.74	0.26	0.44	0	0.12
				Effluent	0.45	0.84	0.06	0.17	0	0.07
				% Removal	20	52	77	64	0	42
Toronto Humber	A.S.	57 mgd	7.4.71	Influent	1.3	1.25	0.55	0.90	0	0.04
				Effluent	0.06	0.35	0.06	0.32	0	0
				% Removal	95	72	89	64	0	100
Windsor	Pr.	13.1 mgd	5.4.71	Influent	0.9	0.92	0.24	0.28	0	0.02
				Effluent	0	0.11	0.06	0	0	0
				% Removal	100	88	75	100	0	100

Table III represents the data from Table I (4 week study) presented in the form of per cent removal of individual metals through the treatment process together with similar data from a 3 week study at the same plant.

These data suggest that most of the common plating metals (Cr, Cd, Cu, Ni and Zn) are at least 70% removed by a conventional activated sludge plant. The exception appears to be nickel which is less than 20% removed.

It is also interesting to note the degree of metals removal achieved by the primary section of the plant. Here, removal efficiency for the common plating metals is somewhat more variable and ranges from 30% for copper to 68% for zinc. This is indicative of the kind of removal efficiency that can be expected from a primary municipal treatment plant.

Data that was obtained from random composite sampling of municipal sewerage systems in Ontario in 1970 and 1971 confirms these general conclusions. Table IV presents a selection of the data obtained from these surveys which are representative of various types of sewage treatment plant.

It is perhaps worthwhile at this point to consider situations where municipal treatment is least effective in removing metals. Many investigators in this field have confirmed that dissolved metals are not effectively removed by municipal treatment processes.

Table V summarizes the findings in this area by Messrs Oliver and Cosgrove of the CCIW.

Those metals that do exhibit some degree of removal in the dissolved form by secondary municipal treatment processes probably react with activated sludge. This reaction may take the form of simple adsorption of dissolved metals on the sludge, or it may be the result of biological degradation of a soluble metal-organic complex, such as an NTA complex, and subsequent precipitation or adsorption of the released metal ion. In any event, it is evident that little removal of soluble

TABLE V

APPARENT REMOVAL OF DISSOLVED METALS
BY AN ACTIVATED SLUDGE TREATMENT PLANT

<u>Metal</u>	Per cent Removal		
	<u>by Primary</u>	<u>by Secondary</u>	<u>by Overall Process</u>
Cd	--	--	--
Cr	<1	<1	< 1
Co	--	--	--
Cu	< 1	56	59
Fe	20	33	47
Pb	< 1	50	50
Hg	--	--	--
Ni	< 1	1	< 1
Zn	< 1	30	> 30

chromium and nickel is achieved by municipal treatment systems and dissolved copper, zinc and lead are only partially removed.

The removal of dissolved metals in municipal treatment systems can only be enhanced by additional chemical treatment. Perhaps fortuitously, the treatment that is being applied to municipal treatment plants in the Great Lakes drainage basin for phosphorus removal represents this type of additional chemical treatment. Table VI summarizes the results of investigations that were conducted in Sweden by Rolf Nilsson on the effects of aluminum sulphate and lime treatment on municipal sewage dosed with dissolved metals.

TABLE VI

PRECIPITATION OF METAL IONS WITH ALUMINIUM SULPHATE AT pH 6.3-7.0
AND CALCIUM HYDROXIDE AT pH 9.5

Metal	Amount Added mg/l	Total mg/l	LANDSKRONA SEWAGE		LOUDDEN SEWAGE	
			Metal Concentrations $\text{Al}_2(\text{SO}_4)_3$	$\text{Ca}(\text{OH})_2$	mg/l after Chemical $\text{Al}_2(\text{SO}_4)_3$	Treatment $\text{Ca}(\text{OH})_2$
Pb(II)	3.4	4.0	0.5	0.3	0.5	0.4
Cu(II)	3.0	3.3	0.2	0.2	0.2	0.3
Cd(II)	3.1	3.1	1.4	0.2		
As(V)	4.2	4.2	1.2	0.6-2.0	1.7	0.1
Cr(III)	3.2	3.3	0.4	0.1	0.2	2.7
Cr(VI)	3.0	3.0	2.3	3.0	0.9	3.0
Zn(II)	2.6	-	1.7	0.2	-	-

These data represent the degree of control that can be achieved by a primary sewage works with chemical treatment added. It appears that lime is more effective than aluminium sulphate as a chemical treatment. It is also evident that some difficulties may be encountered in the removal of hexavalent chromium for reasons previously discussed, namely, that reduction to the trivalent form is necessary before it can be precipitated. Conversely, there appears to be an anomaly in the removal of trivalent chromium from the Loudden sewage by lime treatment. This is believed to be due to the dissolution of chromium hydroxide by excess alkali.

Experience to date in Ontario is that chemical addition for phosphorus removal (principally alum or pickle liquor treatment) does enhance the removal of heavy metals in municipal sewerage systems and this is reflected in increased levels of metals in the sludges from such systems.

Data derived from experiments conducted by the Wastewater Technology Centre CCIW in February 1974, on heavy metals removal by the various types of phosphorus removal process are presented in Tables VII and VIII.

TABLE VII

HEAVY METALS REMOVAL - PRIMARY TREATMENT

METAL		200 mg/1 ALUM	200 mg/1 ALUM + 0.5 mg/1 POLYMER	200 mg/1 ALUM + POLYMER + 100 mg/1 PAC	30 mg/1 FERRIC IRON
Al	Influent	3.297	2.427	4.330	2.112
	Effluent	1.893	0.835	0.440	0.151
	%Removal	42.6	65.6	89.8	92.8
Cu	Influent	0.146	0.168	0.181	0.147
	Effluent	0.038	0.027	0.019	0.057
	%Removal	74.0	83.9	89.5	61.2
Zn	Influent	1.028	1.210	1.348	1.116
	Effluent	0.300	0.278	0.336	0.475
	%Removal	70.0	77.0	75.1	57.4
Fe	Influent	2.707	2.908	2.296	1.513
	Effluent	0.896	0.657	0.176	2.404
	%Removal	66.9	77.4	92.3	-

All values in mg/l - Averages for Experimental Period

TABLE VIII

HEAVY METALS REMOVAL - SECONDARY TREATMENT

METAL		133 mg/l ALUM	200 mg/l ALUM	Baseline	30 mg/l Fe ⁺³
Al	Influent	3.418	1.809	4.864	2.113
	Effluent	0.741	.980	0.299	0.219
	% Removal	78.3	45.8	93.9	89.6
Cu	Influent	0.166	0.149	0.193	0.149
	Effluent	0.013	0.017	0.069	0.029
	% Removal	92.2	88.6	64.2	80.5
Zn	Influent	1.121	1.161	1.293	1.151
	Effluent	0.244	0.879	0.275	0.661
	% Removal	78.2	24.3	78.7	42.5
Fe	Influent	3.307	2.109	2.383	1.506
	Effluent	0.194	0.185	0.235	0.481
	% Removal	94.1	91.2	90.1	68.0

All values in mg/l - Averages for Experimental Period

Nilsson also reports on the effects of sodium nitrilotriacetate (NTA) on precipitation of metals in sewage. NTA is likely to be present in sewage to a significant degree since it is one of a number of replacements for phosphates in detergent formulations, which have been restricted to less than 5% as P_2O_5 by regulations under the Canada Water Act. NTA was found to inhibit the precipitation of metals and, in the presence of NTA, metals such as copper and lead may escape precipitation at pH values in excess of 9.0. NTA metal complexes have been found to be susceptible to biological degradation and it remains to be seen how these competing factors influence metals removal in municipal sewerage systems.

Overall metals removal is only achieved by municipal sewage treatment plants by transfer of the metal to the sewage sludge. Therefore, only those plants which remove, treat or impound sludge are effective in removing metals. While this type of secondary activated sludge plant is common in Ontario, it may not be representative of municipal sewage treatment across Canada.

Extended aeration plants, aerated lagoons and simple waste stabilization lagoons have common application in the prairie provinces, while in the Maritimes municipal treatment may range from none through primary plants to conventional activated sludge. Small community sewage works appear to be common in the Maritimes even in the larger urban centres. Discharges to the ocean, both in the west and east, tend to receive only primary treatment.

Extended aeration plants, aerated lagoons, and stabilization lagoons which normally have no facilities for collection treatment and disposal of sludges do not, over the long-term, achieve significant removal of metals. Because of the nature of these treatment processes, inert suspended solids such as metal hydroxides are not subject to the in-situ sludge degradation incorporated into these systems. Metal hydroxides will, therefore, be lost in the suspended solids in the final effluent from such systems or they may be re-dissolved by anaerobic degradation processes, which generate acidic conditions on the bottoms of lagoons, and be discharged as soluble metal. Short term influent and effluent

analyses are unlikely to identify the degree to which this occurs but it is speculated that long-term studies will probably verify that almost all of the metal that enters such systems is eventually discharged.

In conventional secondary sewage treatment plants, the disposal of sludges also presents a potential source of eventual discharge. Two areas of concern exist and these relate to the contamination of surface waters and ground waters in the vicinity of the disposal site and to the potential adverse effects on agriculture from the utilization of sewage sludge as a conditioner and supplemental fertilizer source on farm land. Both of these aspects of the problem are under intensive investigation. Guidelines for the application of sewage sludge on farm land are being developed in co-operation with agricultural and health authorities which are likely to severely restrict this practice.

At the same time, studies into the sources and disposal of all kinds of industrial solid wastes are being investigated under an Annex to the Canada-United States Agreement on Great Lakes Water Quality. Research activities into the attenuation of metals and other contaminants in the leachate from municipal land disposal sites are also being funded in response to this agreement.

NON-METAL CONTAMINANTS

Almost all of the emphasis of this paper has been directed towards metals contamination of metal finishing effluents. In general, other parameters, with the possible exception of pH and cyanide, are seldom factors in the assessment of metal finishing wastes.

As mentioned at the outset there is little numerical data on parameters such as BOD, COD, oil and grease, phenols and dissolved solids in metal finishing wastes. In considering the effectiveness of municipal treatment in dealing with these parameters it is therefore, necessary to examine the general efficiency of removal of these parameter from municipal sewage.

Secondary sewage treatment processes are effective in removing soluble and insoluble organic matter of all types provided they are susceptible to removal by physical process and/or are biodegradable. On the basis of

BOD and suspended solids measurements and limited COD data, secondary biological treatment is effective in this area.

Primary sewage treatment plants do not remove soluble organic matter and are generally designed to operate on the basis of 50% removal of the total influent BOD.

No sewage treatment process is effective in removing soluble inorganic matter which is not susceptible to precipitation and physical removal. Municipal sewage effluents are a major factor in the influx of inorganic dissolved solids into receiving waters generally.

In this context, it is interesting to note the influence of general urban runoff to the problem of dissolved solids and metals discharges.

The quantity and character of contaminants found on street surfaces is summarized in Table IX which is taken from a United States E.P.A. Report, "Water Pollution Aspects of Street Surface Contaminants", April, 1972.

Storm runoff is a factor in the overall efficiency of municipal treatment plants. By-passing of untreated sewage may occur at sewage treatment plants during periods of high storm water flow.

The extent of by-passing is dependant upon the hydraulic capacity of the sewage works in relation to the storm water flow and the degree of separation of storm and sanitary sewers within the municipality. By-passing may occur at the sewage treatment works or at intervening pumping stations in the system. Most sewage works are designed to provide some form of treatment to storm water flow and new plants are usually designed to treat twice the dry weather flow. However, this capacity may be exceeded during heavy storms or may be reduced by increases in sanitary sewage flow. It is, therefore, impossible to generalize on the precise extent to which by-passing occurs at sewage works across Canada. It is probably reasonable to assume that it occurs in almost all sewerage systems under some circumstances.

There are two conflicting potential effects of high storm water flows and by-passing of untreated sewage. On the one hand the

TABLE IX

MEASURED QUANTITY AND CHARACTER OF
STREET SURFACE CONTAMINANTS lb/CURB MILE

	WEIGHTED MEANS FOR ALL SAMPLES (lb/curb mile)
Total Solids	1400
Oxygen Demand	
BOD ₅	13.5
COD	95
Volatile Solids	100
Algal Nutrients	
Phosphates	1.1
Nitrates	.094
Kjeldahl Nitrogen	2.2
Bacteriological	
Total Coliforms (org/curb mile)	99×10^9
Fecal Coliforms (org/curb mile)	5.6×10^9
Heavy Metals	
Zinc	.65
Copper	.20
Lead	.57
Nickel	.05
Mercury	.073
Chromium	.11
Pesticides	
p,p-DDD	67×10^{-6}
p,p-DDT	61×10^{-6}
Dieldrin	24×10^{-6}
Polychlorinated Biphenyls	1100×10^{-6}

- NOTE: 1. "org" refers to "number of coliform organisms observed"
2. The tabulated values are for all cities tested. They are weighted averages in which data for the larger centres bias the reported loading intensities

untreated sewage may be diluted by clean runoff to the extent that concentration of contaminants are reduced although the quantity remains the same or, conversely, contaminant levels, including metals, may be increased by loadings from street runoff. No data are available to confirm one or the other, although it appears from Table IX that, quantitatively, street runoff would contribute several times more metals than is received in raw sewage.

SUMMARY AND CONCLUSIONS

Municipal sewage treatment processes have varying capacity to remove metal finishing waste components. Treatment plants employing secondary biological treatment processes together with phosphorus removal facilities and sludge collection and disposal are most effective. No treatment and plants which do not collect or isolate sludges are least effective.

Other factors which influence the effectiveness of municipal treatment of metal finishing wastes are:

- 1) interaction between sewage and the waste to precipitate metals;
- 2) the efficiency of the municipal treatment plant;
- 3) the extent of by-passing of untreated sewage during high storm flows; and,
- 4) the ultimate disposal of sludge from the sewage works.

Properly operated municipal treatment systems employing secondary biological processes together with sludge collection or primary works with chemical precipitation facilities remain viable alternatives to the complete treatment of metal finishing wastes at the source, provided that the sludges from these systems do not pose a danger to the environment from their subsequent disposal.

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RECOVERY AND RE-USE OF METALS AND CHEMICALS
FROM METAL FINISHING WASTES

by

G. Mattock
Oxy Metal Industries International
Birmingham, England

INTRODUCTION

Fashions change in environmental matters. In the past twenty years we have witnessed a transition from virtually total neglect of the effects of industrial pollution through to a realisation in responsible quarters of its potentially serious effect; to be followed more recently by a hysterical outburst that gave birth to the technological nonsense of the so-called "zero-discharge concept". The most recent phase, following on the economic recession being experienced nearly worldwide, shows far less discussion of environmental matters: as always, the price calls the action - and indeed some developing countries consider that they have higher priorities than more than just a simple and elementary health concern.

Where does this leave us, then, from within the conglomerate of diverse industries that gives rise to the vaguely named metal finishing industry, in matters of pollution? It clearly demands an approach that endeavours to transcend the vagaries of fashion, but which at the same time shows responsibility and a capability of meeting serious social criticism. It should also be made with money (or its disposition) very much in mind; for it is deceitful or at best naive to ignore the fact that industrialists, however conscious they may be of their commitments to society, are fundamentally motivated by profit. The meeting point must come from the recognition that profit includes a sense of total well being and of overall life quality.

It is the purpose of this paper to try to present an approach that is consistent with industrial reality as well as social need. It is quite possible to regard effluent discharges not just as potential sources of pollution, but as so much wasted profit, and indeed as indicators of industrial inefficiency. Viewed from this angle pollution elimination by the industrialist can be motivated, provided the associated technology is geared to the profit end. This demands of course that there be a total review of the manufacturing process integrating with any other processes designed to minimize pollution, as well as a more coherent approach to the individual problems of the industry concerned.

THE CHARACTERISTICS OF METAL FINISHING WASTES

General Characteristics

Most surface treatment operations involve two main processes. One of these consists of treating the work piece in a solution or in a particular chemical environment, while the other consists of removing excess chemical from the workpiece after treatment. A surface treatment plant thus incorporates a series of process stations interspersed with rinsing stations (see Figure 1). Typical electroplating plant sequences for example are exemplified in Figure 2. This representation is general, going right across the broad spectrum of surface treatment, and starting from preparative processes such as cleaning, pickling, and grinding, through to such protective and finishing processes as heat treatment, electroplating, anodizing, chemical rustproofing and painting, and including also associated decorative operations such as the metallisation of plastics materials.

The most obvious apparent waste deriving from these processes is the rinse water effluent. These rinse waters contain contaminant species that derive from dilution of the original process solution, often to the extent of 10,000-fold reduction in the original process concentration. Because many of the contaminants are toxic or otherwise inhibitory to aquatic life even in very dilute forms, it is generally considered desirable to treat these rinse waters to a high degree of

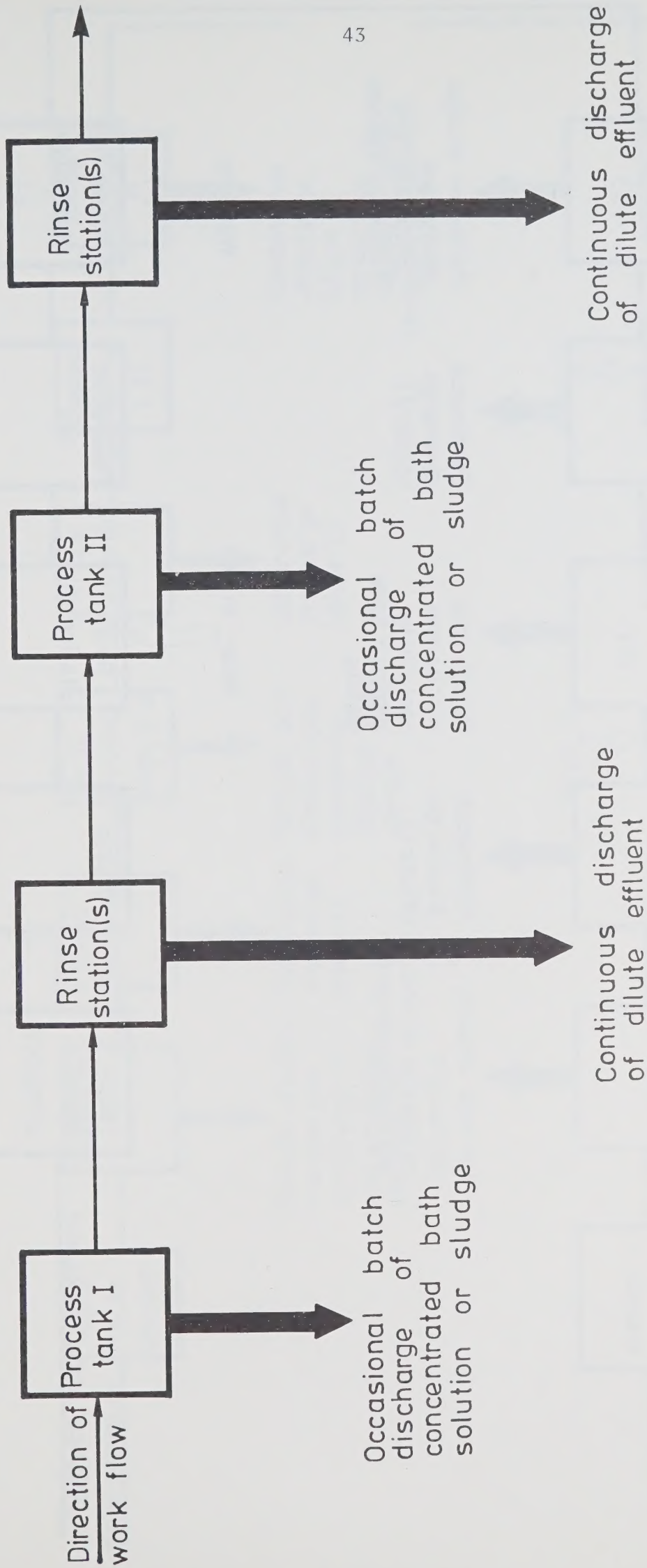


FIGURE 1. THE BASIC PROCESSES IN SURFACE TREATMENT

Example A Zinc Plating

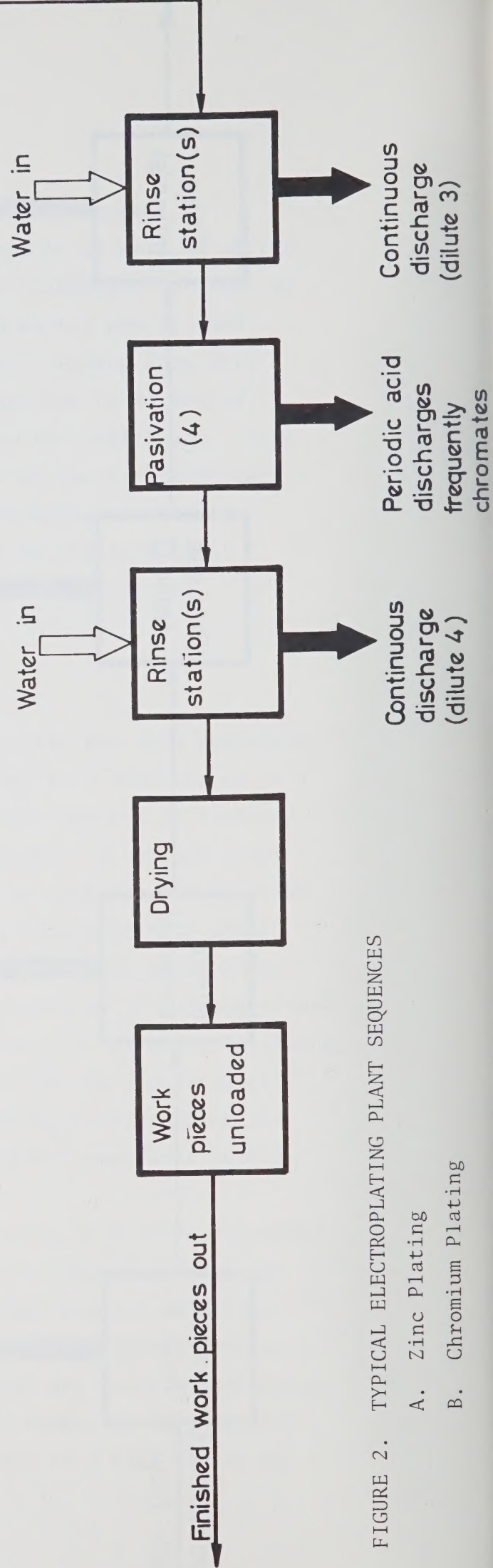
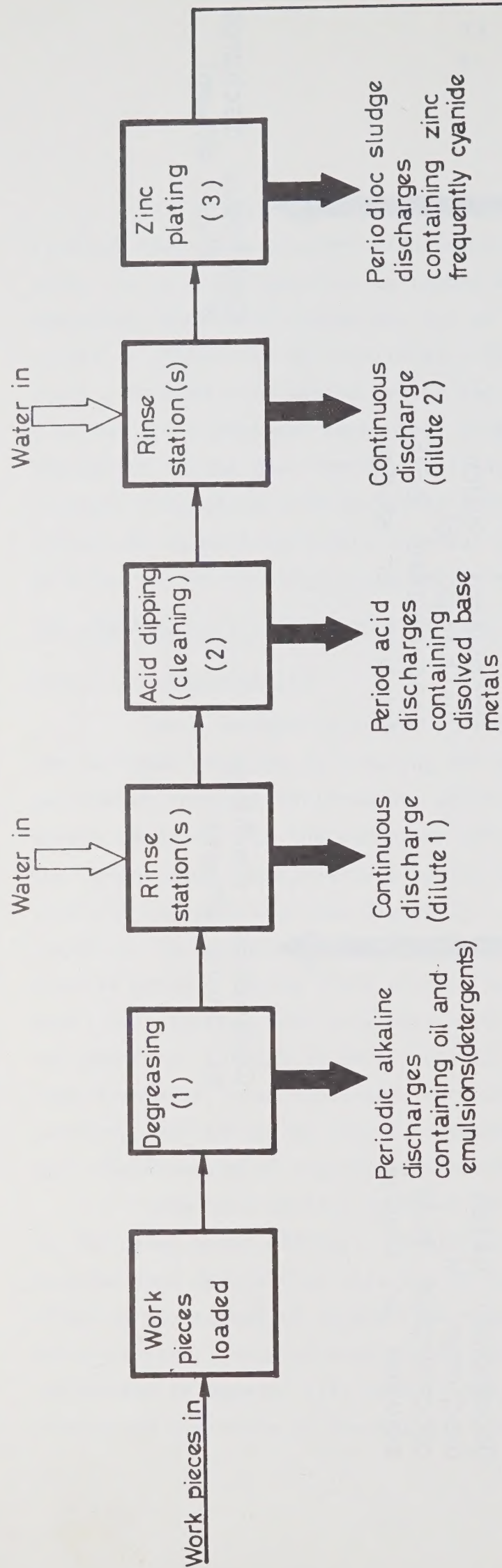


FIGURE 2. TYPICAL ELECTROPLATING PLANT SEQUENCES

A. Zinc Plating

B. Chromium Plating

Example B Chromium Plating

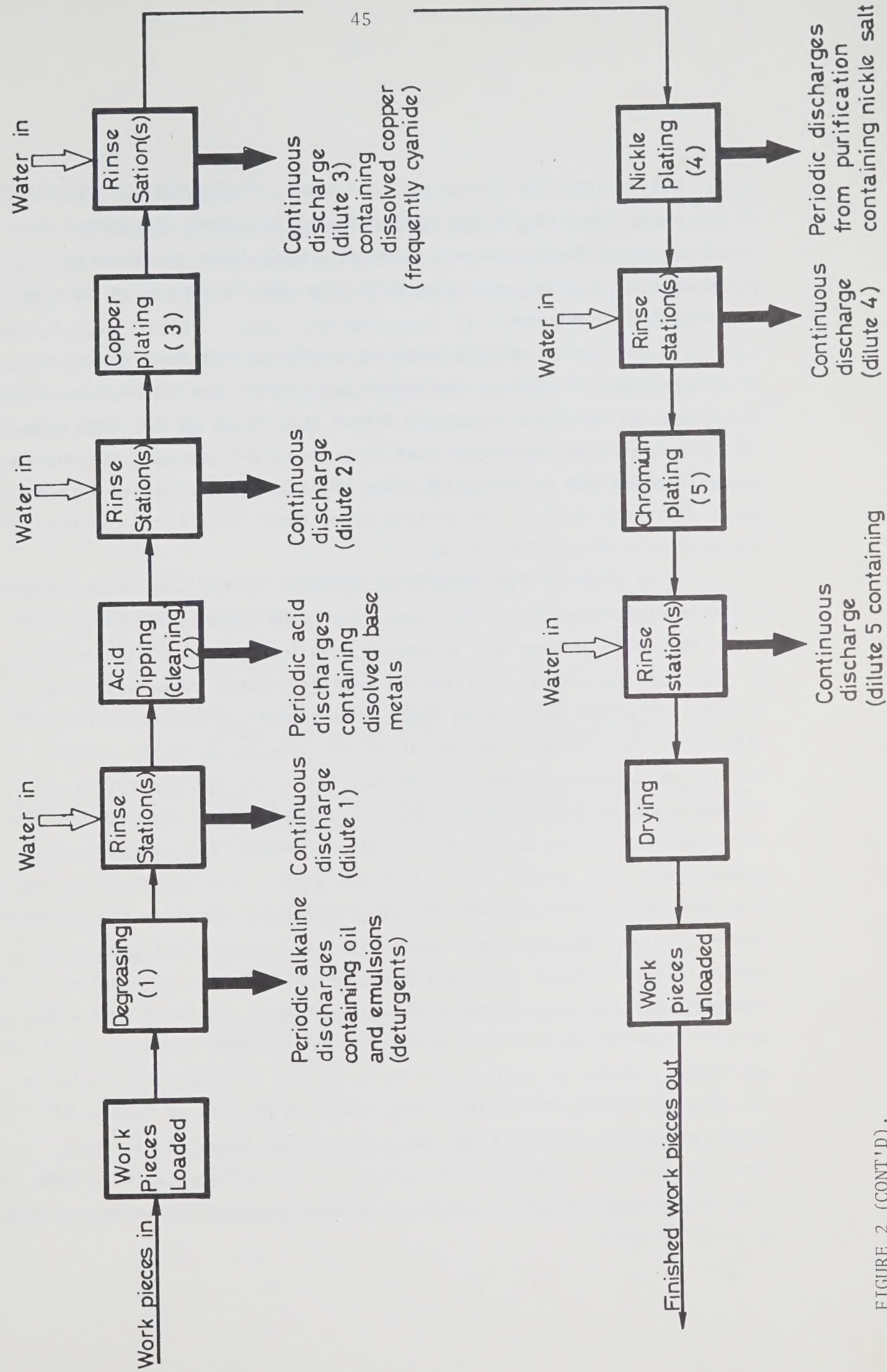


FIGURE 2 (CONT'D).

purity before they are discharged to a watercourse or river. Much of the basic costs of conventional effluent treatment associated with metal finishing discharges are associated with these rinse water purifications, and are usually regarded by the discharger as totally unprofitable investment.

(On the other hand, serious questions have been raised as to whether metal finishing discharges are really sources of heavy metal pollution, at least in sewage. A recent U.S. study of New York sewage characteristics [1] indicates that toxic heavy metals were present in concentrations far in excess of those which could have derived from metal finishing wastes. If nothing else, these analytical results are certainly thought-provoking).

Of greater significance in effluent terms, however, are the periodic discharges that take place when spent process solutions need to be replaced. Either the solutions have to be totally discharged, or a residue following purification process demands removal, giving rise to a highly concentrated waste. In both cases the environmental effects of the effluent can be out of all proportion to the volume. Because the concentrations of chemicals are high, the quantities of chemicals needed for treatment are also considerable, and practice for treatments has varied widely within the industry. One common design approach has been to feed the discharges slowly into the rinse system over the total period between the batch disposal, to allow the effluent system to treat the chemicals automatically. Another has been to handle them on a batch treatment basis by installation of separate treatment vessels and associate dosing equipment. A third method has been to have the chemicals taken away by contractors for disposal elsewhere. (A fourth method, let it be noted, is simply to discharge the chemicals without treatment when there is no risk of discovery by the regulatory authority.) The irony of the situation is that these discharges, although often simpler to treat, are far more harmful in their effects than the rinse discharges to which so much attention is normally paid.

Chemical Characteristics

A review of the chemicals used in metal finishing processes reads like a chemical dictionary. A simplified summary is presented in Table 1, which itself shows what a broad coverage the discharge of chemicals can exhibit. (See also Reference 2). Probably the most significant in terms of quantity and associated polluting effect are the toxic heavy metals, the toxic anions (such as cyanide), acids and alkalis, oils and oil emulsions, and biologically toxic or inhibitory complex-forming agents. Many of the others are restrained by time-honoured recirculatory processes or are negligible in the overall context.

TABLE 1 CLASSIFICATION OF TYPES OF DISCHARGE FROM SURFACE
TREATMENT PROCESSES

<u>Type</u>	<u>Examples</u>
Acids	HCl, H ₂ SO ₄ , H ₃ PO ₄ (and acid phosphates), HF, H ₃ BO ₃ (often discharged with dissolved heavy metals present)
Alkalis	NaOH, Na ₂ CO ₃ (frequently with phosphates, silicates and detergents, and often containing oils and oil emulsions)
Heavy metals in solution	Cd, Co, Cr, Cu, Fe, Mo, Mn, Ni, Pb, Sb, Sn, Zn.
Complex-forming agents	CN ⁻ , amines, NH ₃ , EDTA, NTA, citrate, tartrate, oxalate, gluconate
Organic additives	Aldehydes, ketones, alcohols, fatty and aromatic carboxylic acids, carbohydrates, sulphonic acids, dyes, phenols
Solvents	Trichlorethylene, toluene, xylene, alcohols
Oils, waxes and greases	Sometimes discharged with detergents in emulsified form
Inert solids	Grinding materials, (oxides, carborundum, etc.)

TABLE 1 (cont'd)

SURFACE TREATMENT UNIT OPERATIONSPreparative

Acid or alkaline pickling and etching (of metals)
 Etching (of glass)
 De-rusting (of metals)
 Oil and grease removal (from metals, glass and plastics)
 Machining and grinding (of metals and glass)
 Bonding preparation (of metals)
 Chemical and electrochemical machining (of metals)

Protective and Decorative

Electroplating (on metals and plastics)
 Anodising (of aluminium and magnesium)
 Galvanising
 Rustproofing
 Enamelling
 Immersion coating (of metals)
 Metallisation (of glass)
 Chemical and electrochemical polishing
 Passivation (of treated metal surfaces)
 Painting and lacquering
 Surface hardening (of metals)
 Electroforming (on metals)
 Colouring and bronzing (of metals)

SOME INDUSTRIES USING SURFACE TREATMENT FACILITIES

Automotive
 Electronics (TV, radio, telecommunications, etc)
 Iron and steel (fabrication and processing)
 Non-ferrous metal (fabrication and processing)
 Foundry
 Furniture
 Food equipment
 Jewellery
 Aircraft
 Locomotive
 Consumer durables
 Marine
 General engineering
 Architectural
 Machine tool
 Fancy goods
 Toys
 Medical equipment
 Cosmetics

Shifts occur from time to time in the discharge characteristics as a result of changes in types of processing chemicals used within the industry. Some time ago as a response to the emotional, political and public reaction to cyanides, a move was made to reduce the cyanide content of processing chemicals. The unfortunate side effect of this was the introduction of other species which caused greater difficulty in the treatment of the discharges than occurred with the cyanides; so it cannot be said that the changes have always been improvements. Indeed even now one of the main problems so far as treatment and indeed potential toxic effects with an increasingly widely used range of chemicals has not been adequately realised. This is associated with the use of complex-forming agents within process chemical formulations having the effect of binding metal ions (or otherwise of creating stable species) that are resistant to breakdown in the normal effluent treatment processes, but which may slowly decompose in a normal aquatic environment to give rise to residues that are toxic or biologically inhibitory. Much of the responsibility for this must go to the developers of metal finishing formulations, but in realistic terms it must still be recognised that these formulations are made in order to improve products and to meet customer demands: it is still a matter in the final analysis of consumer attitudes.

THE CASE FOR RECOVERY

It is almost platitudinous nowadays to talk about the desirability of recovery in the environmental context. Too often it is insufficiently appreciated however that recovery is only attractive to the recoverer when there is incentive that is either financial or statutory. In only a few cases is this incentive evident, and indeed it is surprising that regulatory authorities have not simplified their own task and at the same time contributed to the achievement of their objectives by developing statutory approaches that encourage recovery positively rather than incidentally. Attention has generally been concentrated on definitions of discharge qualities by way of concentrations, with little thought being given to restriction of total flows and total loads. As a result metal finishing waste treatment had until recently tended to be concerned simply with the

de-toxification of discharging streams, with small attention given to the process or processing from which the effluent derived.

(Recirculation systems for rinse waters have been available and been used for several years, but rarely as an automatic preference on statutory grounds.)

What is frequently not appreciated (or applied) is that attention within the process plant by in-house modifications can usually reduce the magnitude of the effluent problem both in terms of the quantities of chemicals and in terms of discharge flows to a substantial degree. More recent process plant designs have recognised this and have incorporated flow reduction systems of various kinds. (These can include increased drainage times from the process tank, fog spray rinsing over the process tank when the process solution is warm, dragout/recovery stations, more extensive use of counterflow rinsing, good agitation in the rinse tanks, spray rinsing, hot water rinsing, use of wetting agents to reduce carryover, control of rinse water input linked to work input, and so on.) It is frequently true, moreover, that the extra expenditure of money and space to provide double or triple counterflow systems, draining stations and the like is not only less than that required to achieve effluent treatment for large flows; these procedures also cut down operating costs from the chemicals saved and from the corresponding reduction in quantities of chemicals required for treatment. Process chemicals can be lost by discharge into the rinse system to a surprising extent. For example, in chromium plating it is broadly true that no more than 10% of the total consumption of process chemicals is used in electrodeposition, 17% going through the exhaust stack and 73% being lost with dragout. Likewise nickel salts added to a process solution to make good the losses that occur can be equivalent to 25% - 50% of that actually deposited on the article being plated.

In the case of spent process solutions the costs of treatment can usually be quite substantial, in view of the significant quantities of chemicals involved. The recovery possibilities with many of the solutions, although technologically feasible, have until recently largely remained unexplored in practice.

At the base of this there is a problem that is not connected with recovery itself as a desirable operation. Where the metal finisher is able to carry out a process that recovers a chemical in the form in which he would normally expect to re-use it directly in his plant then, economics permitting, he will consider its installation. Where however the recovery material is of a derived nature that has a value but is not directly re-useable in his plant, then he is introducing a further business activity (by way of needing to establish sales of the recovered material) that is foreign to his principal form of business. Metal finishers are not in the recovery business per se, and generally will only recover when this assists their normal operations directly.

A further point related to the fact that recovery systems usually demand somewhat higher initial capital outlay, albeit with the promise of cash funds available, the industry, being composed to a large extent of small and medium sized organisations, prefers to meet its costs on an operating basis rather than an investment one so far as this is possible. As a result, there has been overall little real movement towards implementing the technological possibilities that have been available.

RECOVERY TECHNIQUES

Rinse Systems

The initial approach can be to preserve water. It is a well attested fact that where effluent treatment is demanded, the capital costs are directly related to the flows concerned as well as to the complexity of the chemicals in the discharges. All in-house procedures to reduce water consumption, therefore, have a beneficial effect on subsequent treatment economics and by intelligent use of the various in-house devices that are available it is often possible to reduce flows by as much as 80% - 90%. It is rarely more difficult to treat a concentrated rinse than a dilute one, and the operating costs so far as chemicals are concerned, other things being equal, are virtually the same.

The alternative idea, that of using large volumes of water to dilute the effluents to a point where they are acceptable in the discharge, can be used where water availability and the receiving watercourse can tolerate the practice. In an increasing number of circumstances, however, this does not apply. Even where it does, some treatment procedures are usually necessary, such as the destruction of cyanides, the reduction of chromates, and pH adjustment, and here again the use of large volumes of water demands the installation of large treatment units. If dilution is to be applied to meet stringent discharge limits it is in fact better to do so after the treatment of the more concentrated rinses than before. This then brings in the question of the volumetric proportion of discharge flows to the total flows in the receiving stream or sewer, and thus again the procedure should be studied very carefully within the overall context before it is embarked upon.

Having achieved any necessary and feasible degree of concentration of rinses by in-house conservation, it is then often possible to reduce the discharge quantities even more. The techniques concerned have been well described elsewhere, including deionisation [3], Controlled Recirculation [4], and chemical rinsing with following water rinsing that is subject to recirculation (as developed by Lancy and co-workers) [5]. Deionisation is not usually beneficial when the rinses have been concentrated and, from the point of view of water recovery alone, has only limited attraction for most metal finishers. The main advantage in using deionisation is when very high quality water is needed for particular rinsing stages, where the supply water quality is poor, or where the species present in the rinses are of a nature difficult to treat continuously; in the last case ion exchange transforms the effluent into a periodically discharged concentrate than can then be subjected to separate specialised treatment.

More recently attention has been directed towards the possibilities of closed loop recovery of chemicals from rinses where valuable solutions are concerned. For many years recovery practices of a simple kind have been pursued with precious metal plating systems, but relatively little attention has been paid to solutions involving chromic

acid, nickel, copper etc. The principal approaches now being applied involve evaporation, reverse osmosis and ion exchange. Each exhibits somewhat different characteristics, and are worthy of relative review.

Evaporation

This represents a particularly good example of the possibilities of nearly closed loop recovery of both the original process solution and of the rinse water, as represented in a generalised form in Figure 3. Examples of typical evaporator systems that have been applied to recovery of metal finishing solutions are diagrammatically represented in Figures 4, 5, 6 and 7. They have been used for chromic acid, bright nickel plating solution, copper sulphate, silver cyanide, copper cyanide and zinc cyanide recovery, to name a few of the applications. Most success has been achieved with chromic acid, nickel and simple copper salts, inasmuch as the original process solution can virtually be recovered as its original form. The position is less satisfactory with solutions containing volatile species such as cyanide, and where foaming may occur.

One of the arguments frequently raised by metal finishers to recycle systems of this kind is connected with the fact that the time-honoured method of maintaining equilibrium purity in the bath solution is by the drag-out being removed from the system in the rinse water. Any recycle system recovering the solution from the post-treatment rinses will of course return the impurities to the bath and disturb this equilibrium condition. If this assumption is analysed carefully, however, it is possible to determine whether the fears are real or imaginary, and in fact it has been found not only from theoretical analysis but also from practical experience (provided certain detailed precautions are taken and certain pre-process rinsing procedures are followed) then little or no difficulty ensues.

Nevertheless it is true to say that 100% recycle of recovered process solution could in time in some cases bring about plating difficulties. There is a simple answer to this, and it consists in not seeking to achieve 100% recycle, but something less. By reserving a small proportion (5 - 10%) of the recovered process solution and not

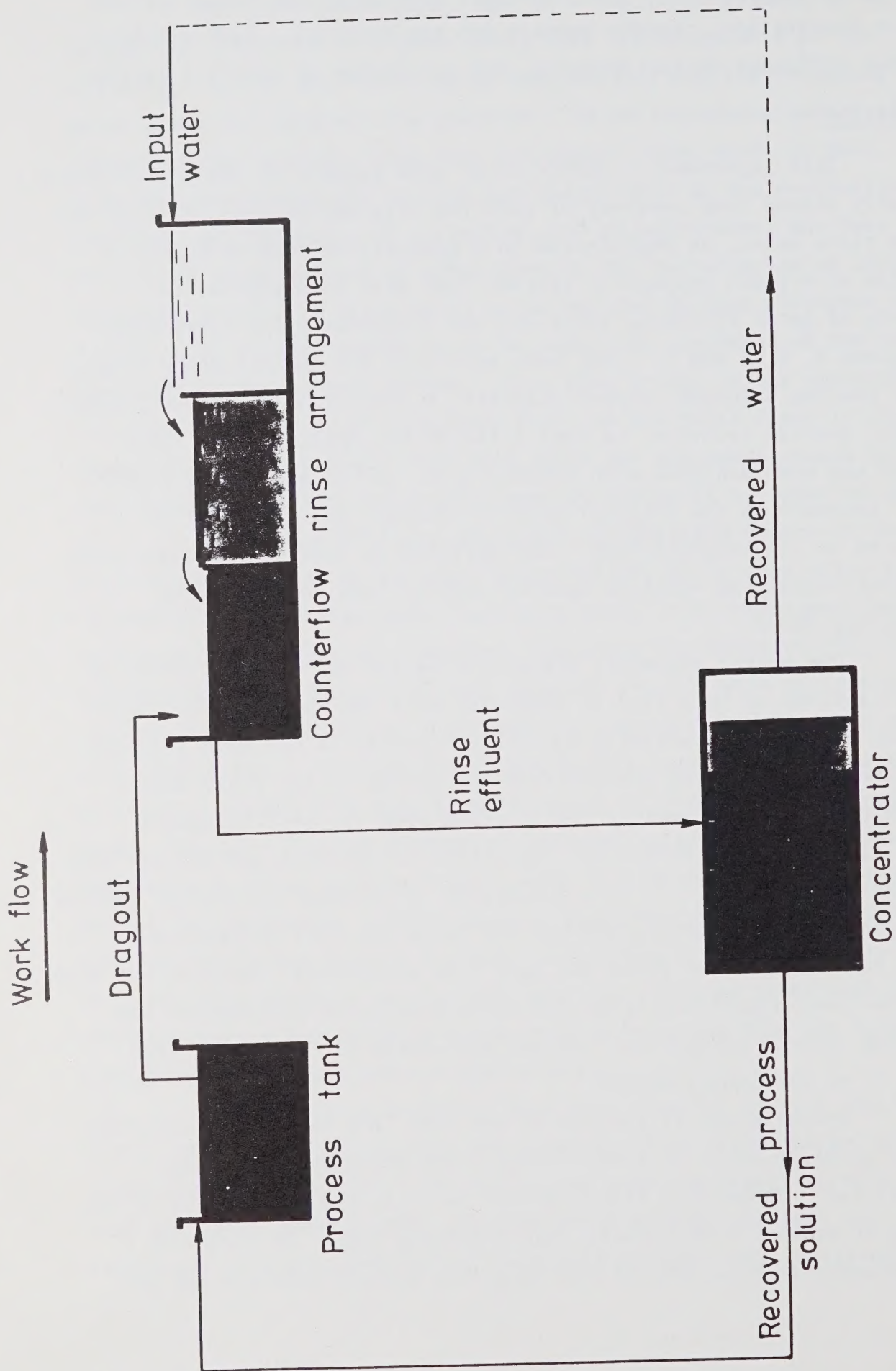


FIGURE 3. CONCENTRATION SCHEME FOR RECOVERY OF PROCESS SOLUTION AND RINSE WATERS

Recovery Processes by Evaporator (Corning type)

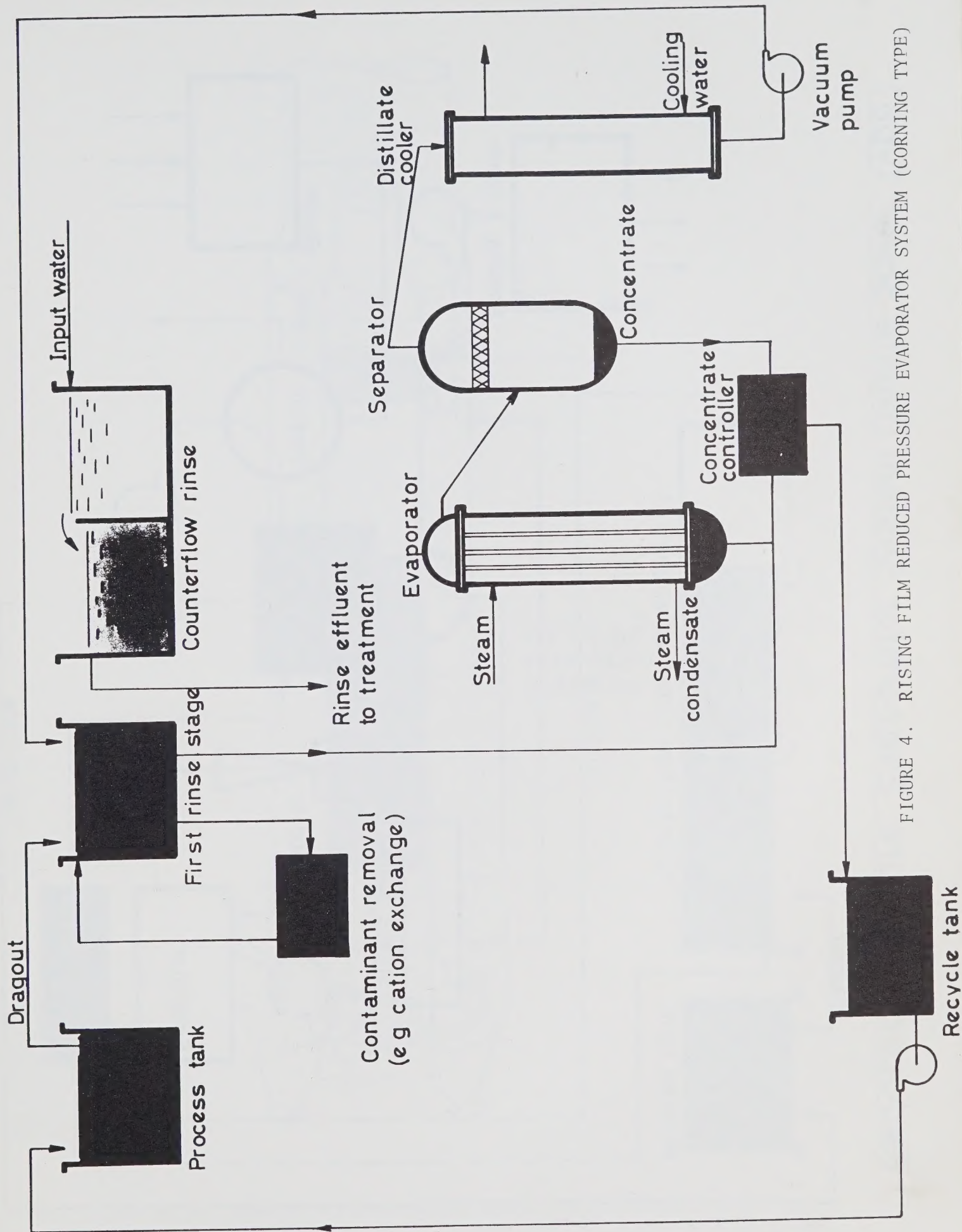


FIGURE 4. RISING FILM REDUCED PRESSURE EVAPORATOR SYSTEM (CORNING TYPE)

Reduced Pressure Evaporator System (Waste Saver Type)

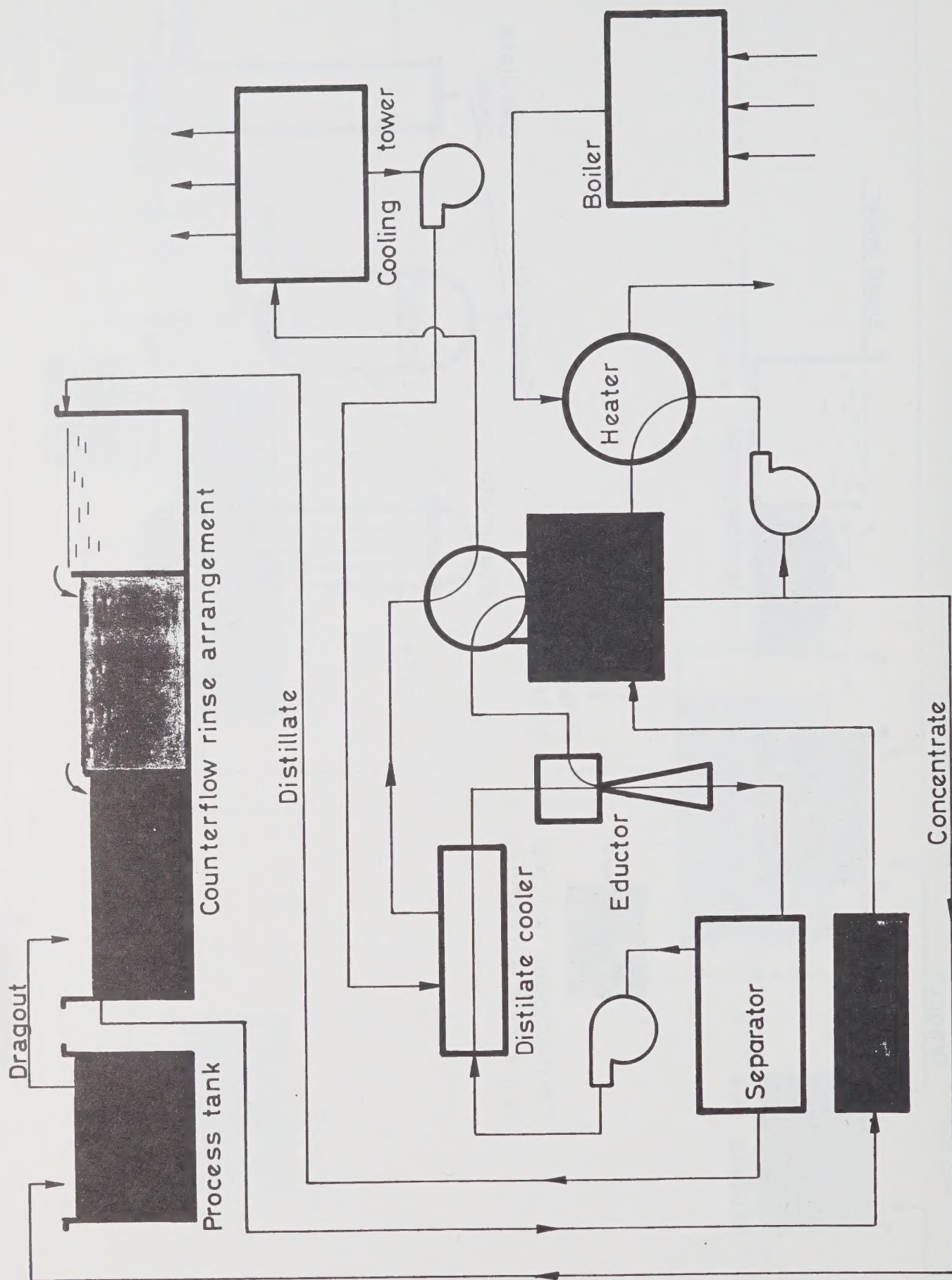


FIGURE 5. SUBMERGED TUBE EVAPORATOR (WASTESAVER TYPE)

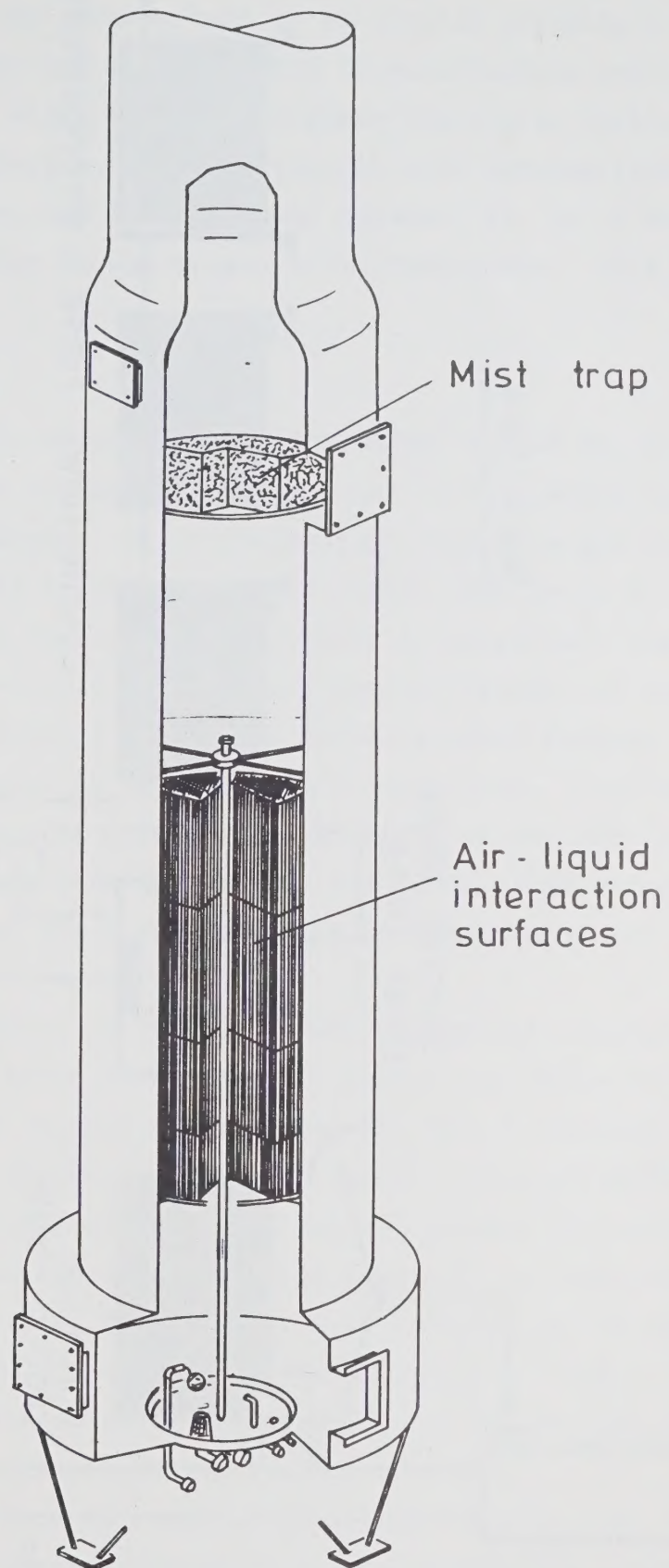


FIGURE 6. FORCED AIR EVAPORATOR SHELL (EBARA TYPE)

Application of Forced Air Evaporation to Chromium Plating Systems

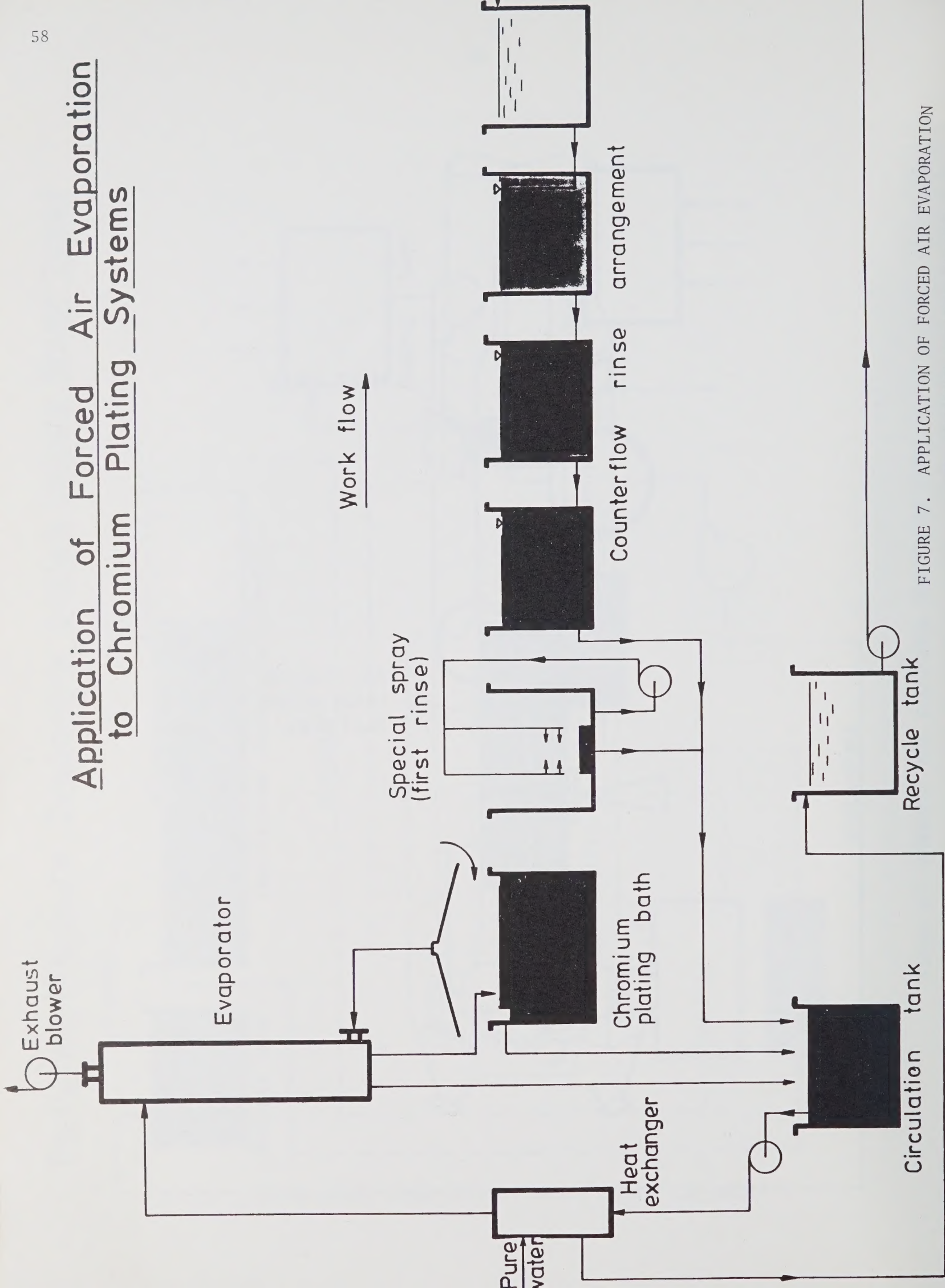


FIGURE 7. APPLICATION OF FORCED AIR EVAPORATION
TO CHROMIUM PLATING SYSTEMS

returning this to the process bath it is usually possible to achieve an equilibrium condition corresponding to satisfactory work, and equivalent to that which would apply where the system involves losses through rinse discharges. This residue is both concentrated and relatively valuable, and there is good argument for it to be further processed rather than be discharged indiscriminately. This is referred to again below.

Reverse Osmosis

Relatively recently applied in metal finishing, this has been the subject of much enthusiastic promotion. Like evaporation it is a concentrating process. It is frequently claimed to use less energy, although its capital costs are usually higher than those for evaporators (other things being equal) and it provides a concentrate that is not in itself directly re-usable and requires further concentration, e.g. by evaporation. The overall balance of attractiveness between the two alternative procedures is therefore still uncertain. Nevertheless it would seem that the same principle would apply as for evaporators, viz. that a desirable long term approach is not to use 100% recycle but to reserve a portion of the recovered solution for alternative recovery value.

The essential principle of reverse osmosis consists of reversing the well known phenomenon of spontaneous diffusion of dilute solution or solvent through a semi-permeable into a stronger solution incorporating that solvent, whereby an osmotic pressure differential is created. In reverse osmosis this natural osmotic pressure is counter-acted by the application of an opposing pressure, so that the net result is a transfer of solvent from the stronger solution to the weaker solution (or solvent) through the membrane. (See Figure 8.) Thus a solution can be separated into a more concentrated form than its solvent and a degree of purification and concentration thereby effected.

Various types of membrane configuration are used, based either on cellulose acetate materials or on synthetic polymers (such as polyamide). Figures 9, 10, 11 and 12 illustrate typical reverse osmosis

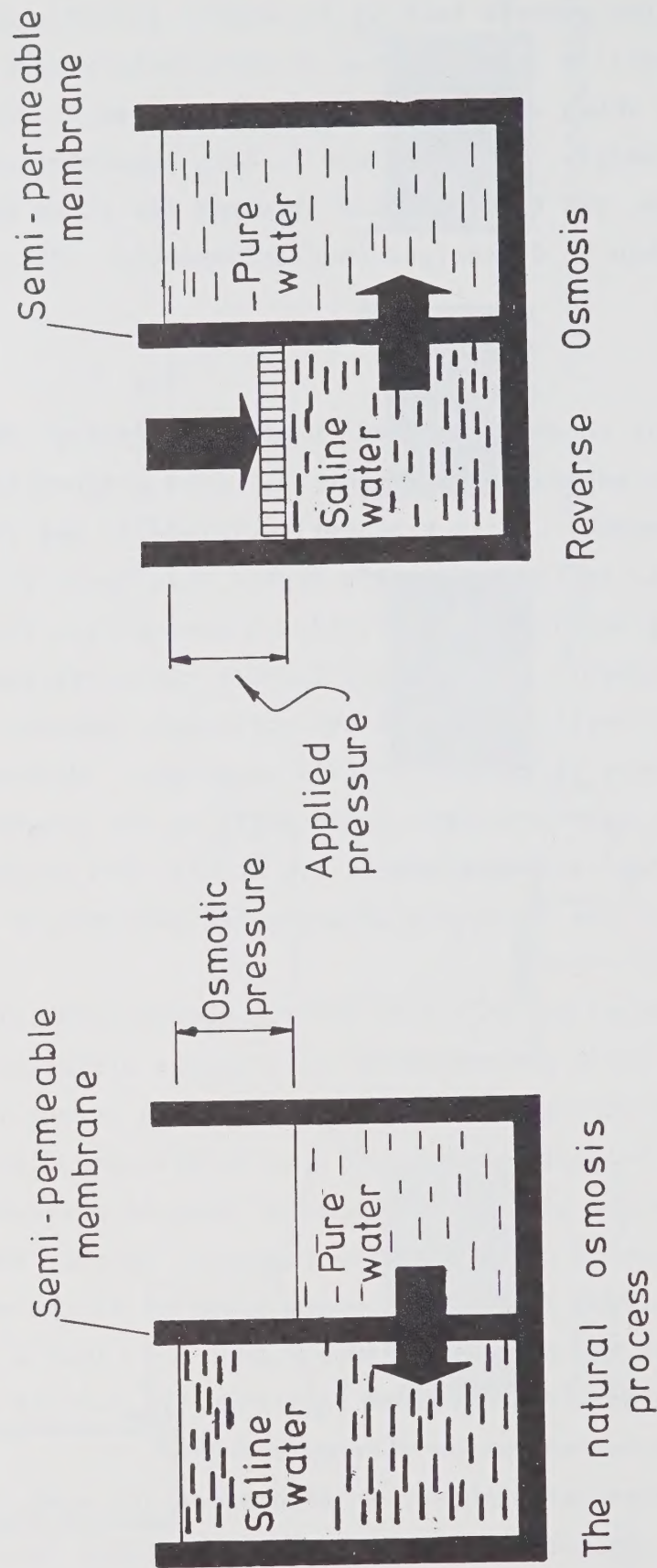


FIGURE 8. THE PRINCIPLES OF REVERSE OSMOSIS

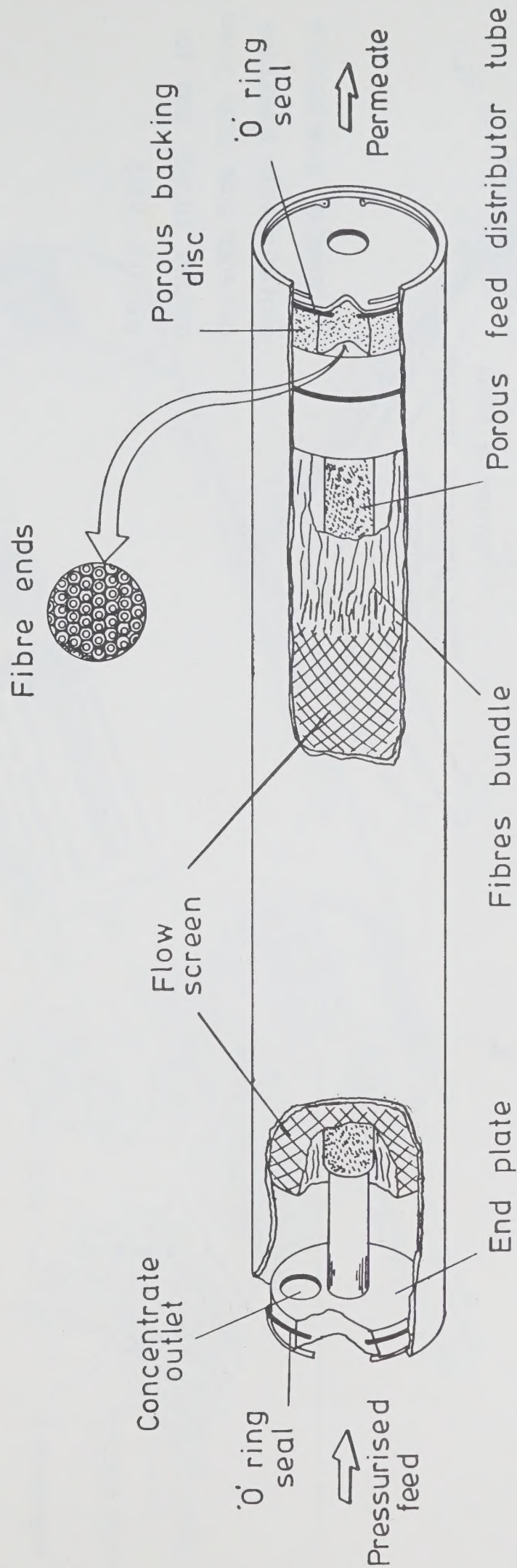


FIGURE 9. HOLLOW FINE FIBRE REVERSE OSMOSIS MEMBRANE (DU PONT TYPE)

Feed side spacer

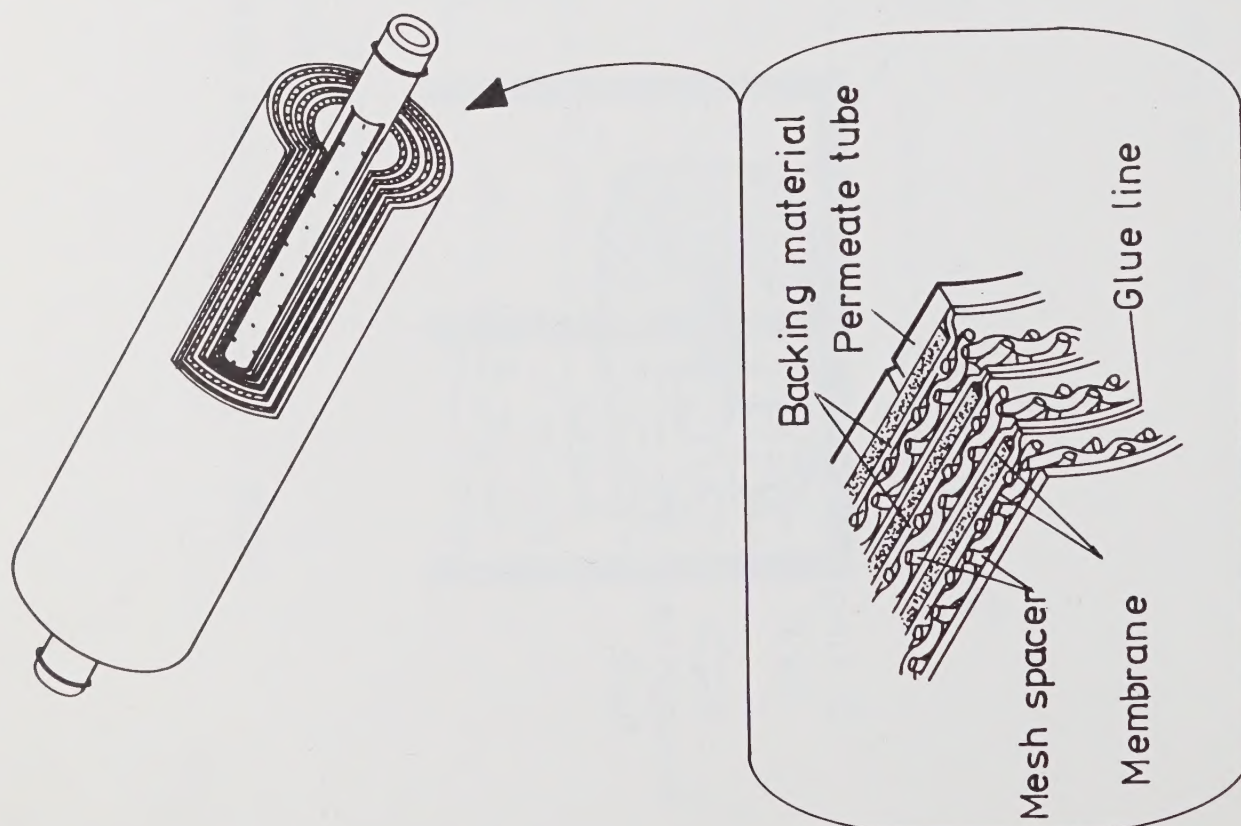
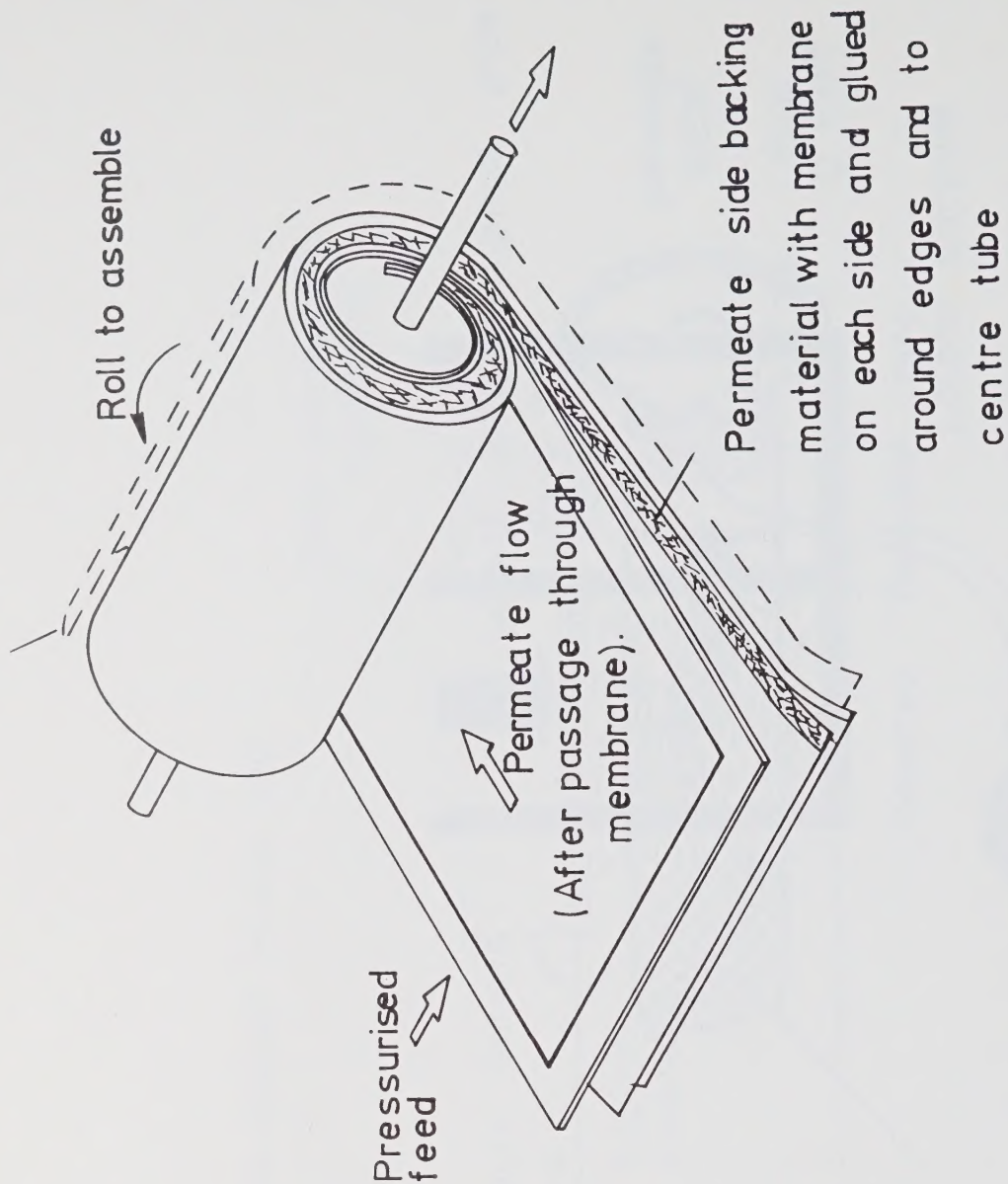


FIGURE 10. SPIRAL WOUND LEAF REVERSE OSMOSIS CONFIGURATION (GULF ROGA TYPE)

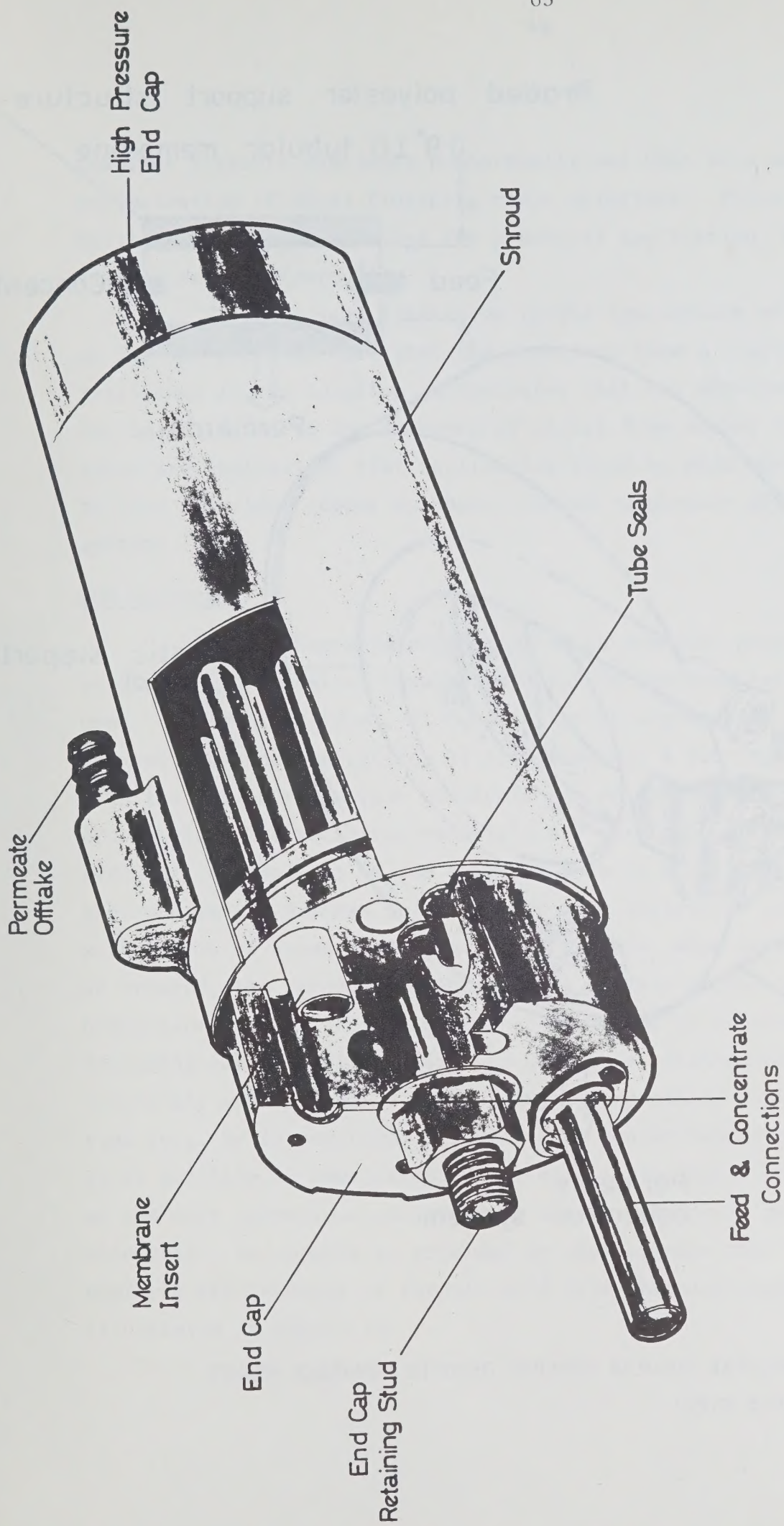


FIGURE 11. TUBULAR REVERSE OSMOSIS MEMBRANE MODULE (PCI TYPE)

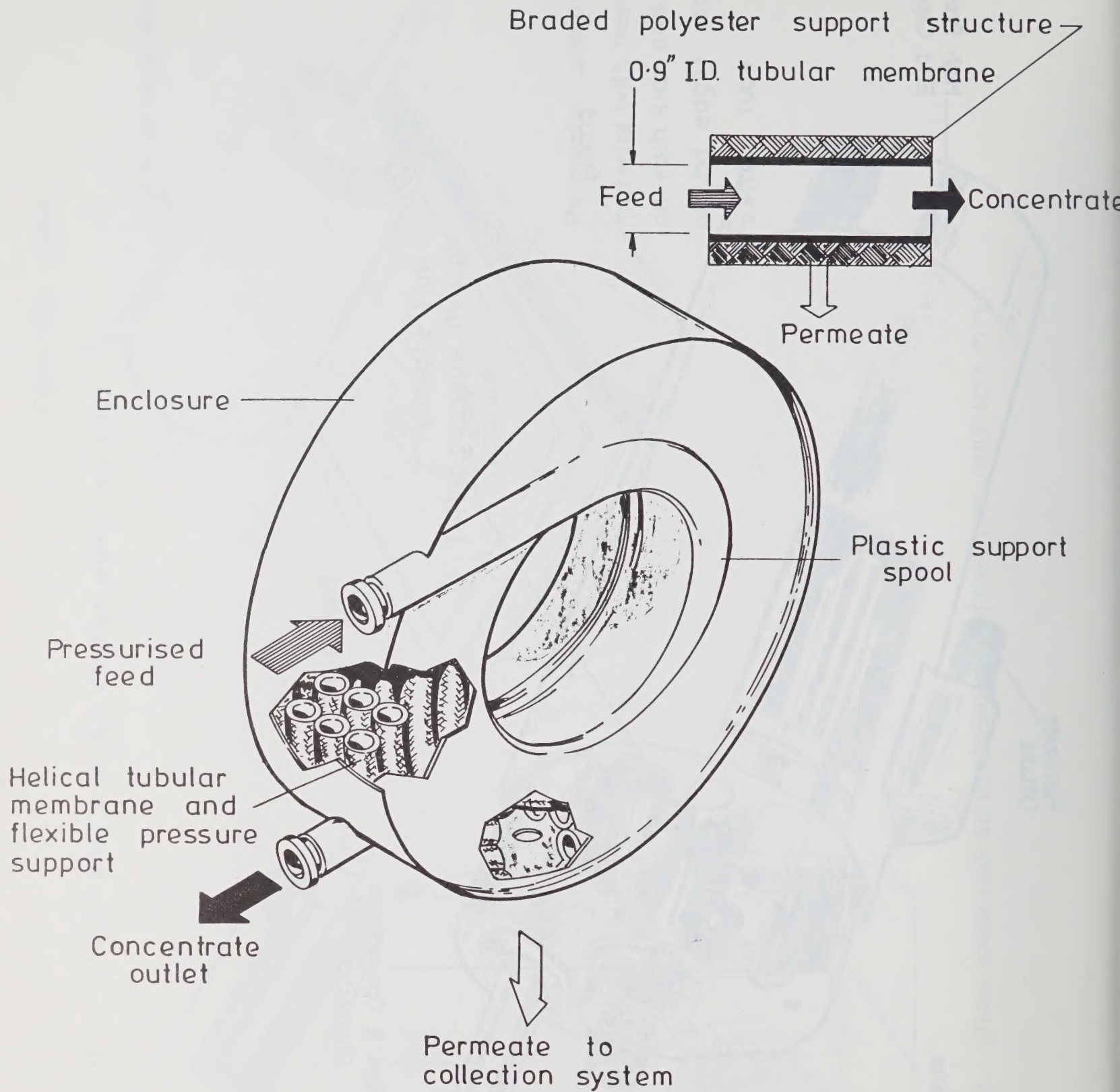


FIGURE 12. HELICAL TUBULAR REVERSE OSMOSIS MEMBRANE MODULE
(OXY TYPE)

membrane segments available commercially and that have been applied to concentration of metal finishing rinse solutions. These modules are built up into modular arrays for practical application, for example illustrated in Figure 13.

The practical limitation in the application of reverse osmosis so far has been the fact that the membranes show a limited chemical resistance in the solution concentrates that are obtained. Main usage has been limited to the recovery of nickel from nickel rinses, although there are indications that application could be made more extensively to zinc chloride, copper sulphate, nickel sulphamate and nickel fluoborate systems [6].

Ion Exchange

Ion exchange recovery applied to specific process solutions as opposed to deionised water recirculation has been relatively little used. As in other cases, it demands strict segregation of rinses to prevent cross-contamination; it also involves a running cost associated with the use of regenerant chemicals for rejuvenating resin adsorption properties. The recovered materials are obtained in the regenerant effluent, and are not in the original form in which they have been employed in the process solution, but as a derivative salt, together with excess of regenerant agent. For example, when nickel rinses are so treated, the recovered solution will contain nickel chloride and hydrochloric acid (if the latter has been used as regenerant on the adsorbing cation resin). Also the solutions obtained are usually relatively weak (about 4% salt strength) and demand further concentration (e.g. by evaporation) before re-use can be considered. Nevertheless it is possible in some cases by suitable resin choice and arrangement of the unit operations concerned to obtain relatively pure recovered materials. An example is provided by the sequence that has been employed for recovery of chromic acid from chromium-containing rinses, illustrated in Figure 14.

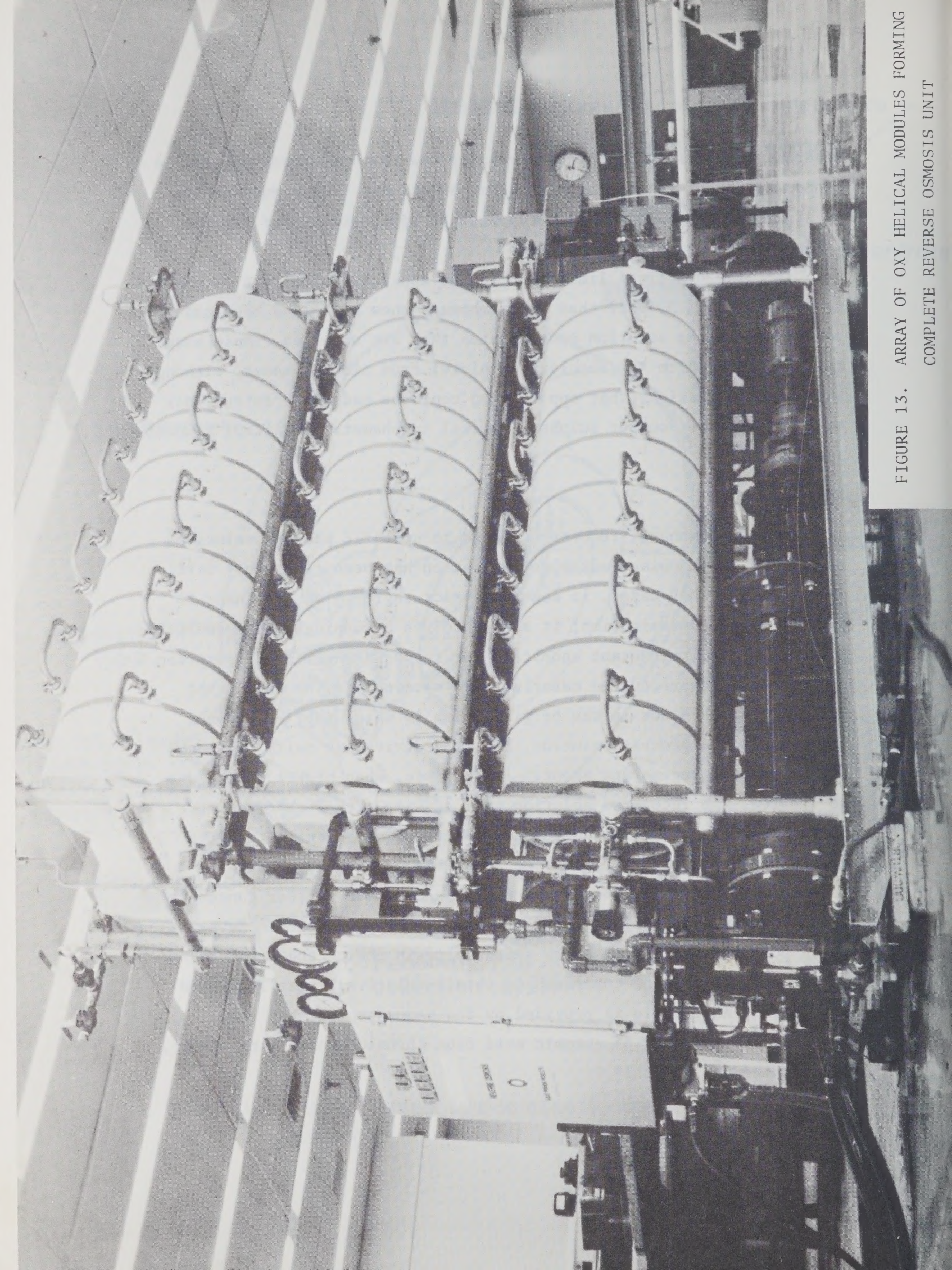


FIGURE 13. ARRAY OF OXY HELICAL MODULES FORMING
COMPLETE REVERSE OSMOSIS UNIT

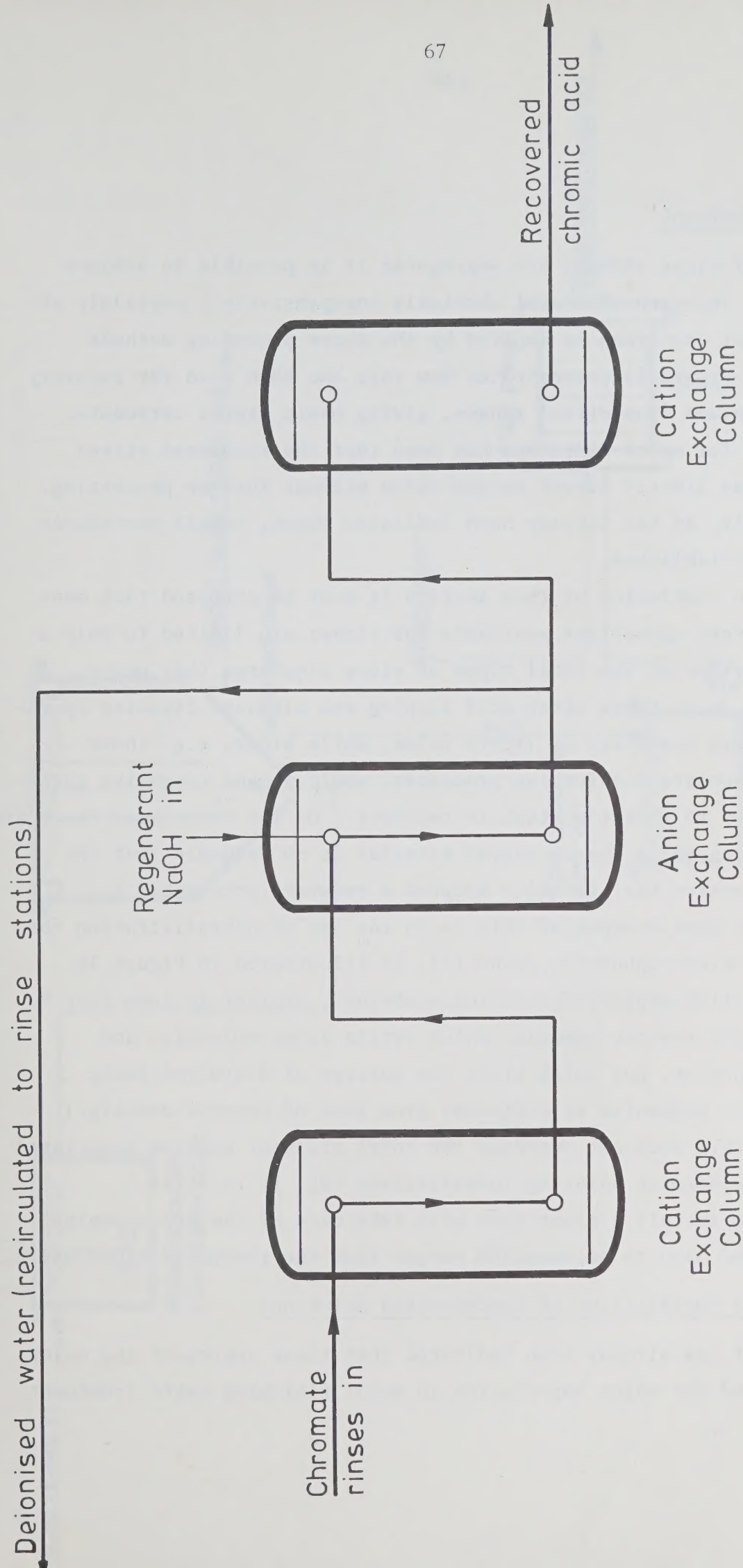


FIGURE 14. THE RECOVERY OF CHROMIC ACID FROM RINSES BY ION EXCHANGE

Chemical Treatment

If rinse streams are segregated it is possible to achieve significant recovery of useful chemicals inexpensively - certainly at lower capital cost than is implied by the three preceding methods described. Figure 15 demonstrates how this has been used for recovery of nickel values from nickel rinses, giving basic nickel carbonate. The problem for metal finishers has been that the recovered nickel carbonate has limited direct re-use value without further processing. Alternatively, as has already been indicated above, resale procedures have to be established.

In conclusion of this section it must be stressed that many of the recovery operations available for rinses are limited to only a small proportion of the total types of rinse discharge that occur. Many rinses, e.g. those after acid dipping and alkaline cleaning operations, contain chemicals of little value, while other, e.g. those following chromate passivating processes, would demand extensive treatment in order to effect worthwhile recovery. On the other hand there are specific cases where the recovered material is so valuable that the industry practice has virtually adopted a recovery procedure; a particularly good example of this is in the use of ultrafiltration for recovery of electrophoretic paint [7], as illustrated in Figure 16. (Ultrafiltration employs filtration membranes, similar in some ways to those used for reverse osmosis, which retain large molecules and colloidal species, but which allow the passage of dissolved ionic species. Its mechanism is different from that of reverse osmosis.) Even there this does not overcome the total effluent problem associated with electrophoretic painting installations [8]; it is still necessary to install a plant that will take care of the pre-cleaning processes and also to accommodate purges from the recovered rinse water.

Recovery and Purification of Concentrated Solutions

It has already been indicated that these represent the major challenge and the major opportunity in metal finishing waste treatment.

pH controlled Na_2CO_3 addition

Nickel rinses in

Nickel carbonate
precipitation stage

Treated nickel rinses out

Settlement stage

Wash water

Nickel carbonate
slurry out

Filter press

Filtrate / wash water out

Slurry consolidation
stage

Recovered nickel carbonate

FIGURE 15. RECOVERY OF NICKEL CARBONATE FROM NICKEL RINSES BY CHEMICAL TREATMENT

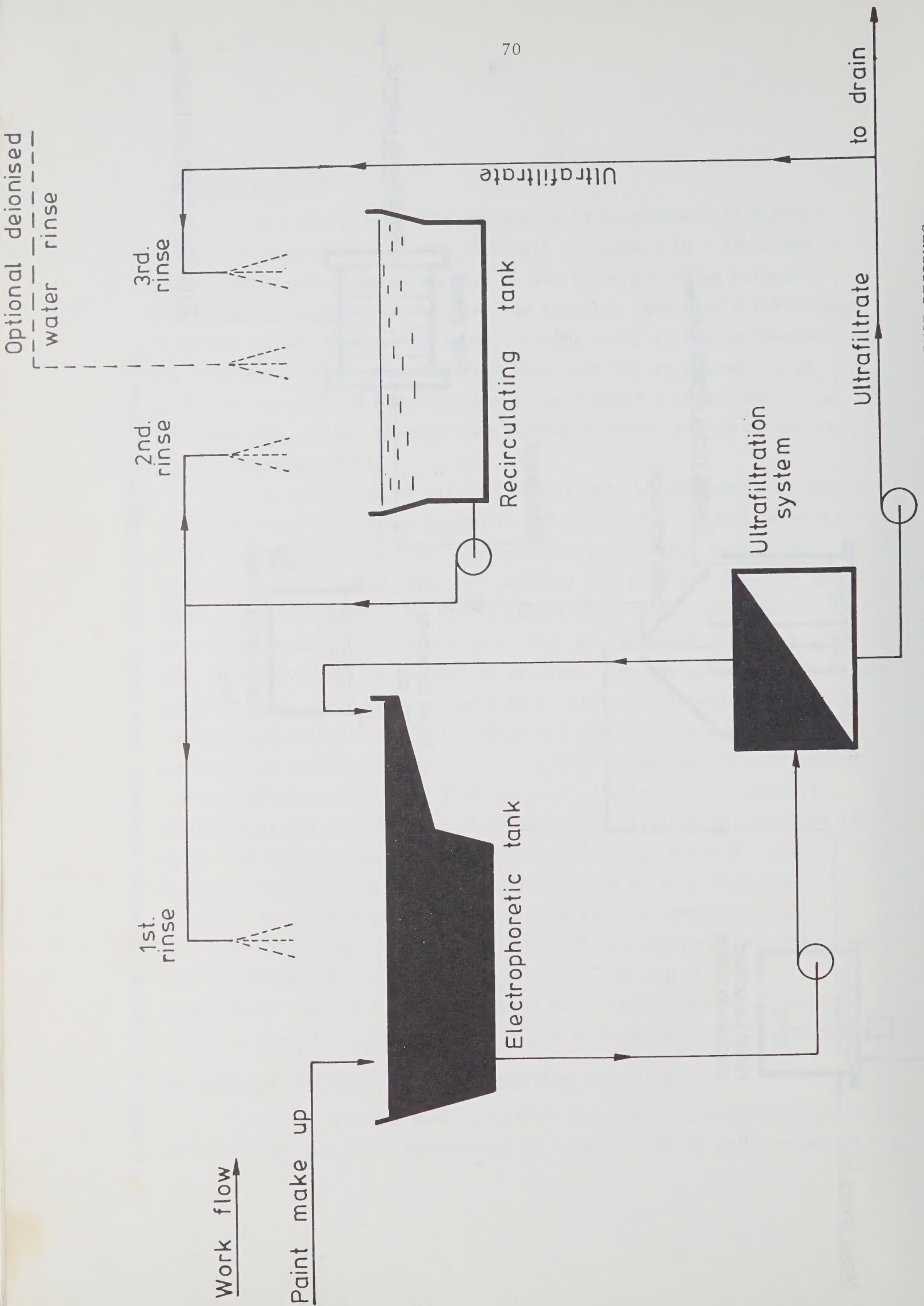


FIGURE 16. APPLICATION OF ULTRAFILTRATION TO RECOVERY OF ELECTROPHORETIC PAINT FROM RINSE RESIDUES

If the practice of treatment for simple disposal can be changed from its present form into a more constructive procedure not only will pollution reduce but also overall industry economics improve.

In broad outline the kinds of concentrate concerned can be classified into a few different types. Firstly there is the spent product, such as dipping acids, alkaline cleaners, cyanide salts, passivating solutions, and phosphating solutions that need to be disposed of fairly regularly, e.g. weekly or monthly. Secondly there are the various residues that derive from periodic purification of solutions in process tanks; these include sludges, e.g. from zinc cyanide plating baths, residues from purification of nickel plating solutions, discarded chromic acid dragout solutions and so on. Into a third class may be grouped the recovered materials that may derive from rinse recovery and purification procedures as already outlined in the preceding section.

Various technologies are in fact available to achieve economic recoveries even for solutions which to the metal finisher have limited re-use value. Economic viability in these cases is often a function of scale of operation; a notable example of this is hydrochloric acid. In others, recovery may best be practised by the metal finisher himself; and here a good example is in the removal of oil (with simultaneous cracking of oil emulsions) from alkaline cleaner solutions by ultra-filtration [9]. (See Figure 17.)

Various ion exchange procedures have also been mooted in the past to achieve purification, but have not shown themselves to be adequately economic. One of the expense features of ion exchange is the regenerant reagents. These are not only costly but produce effluents that themselves demand treatment. However, in some cases these spent regenerants contain useful components, and recently the idea of recovering both these valuable materials and also the regenerant reagents themselves has been developed [10]. This changes the position completely. Figure 18 illustrates one application involving the recovery of sulphuric acid solution from spend liquor containing residual acid and dissolved copper, and zinc from brass pickling. The spent acid is passed through a cation exchange column and the original acid value thereby recovered.

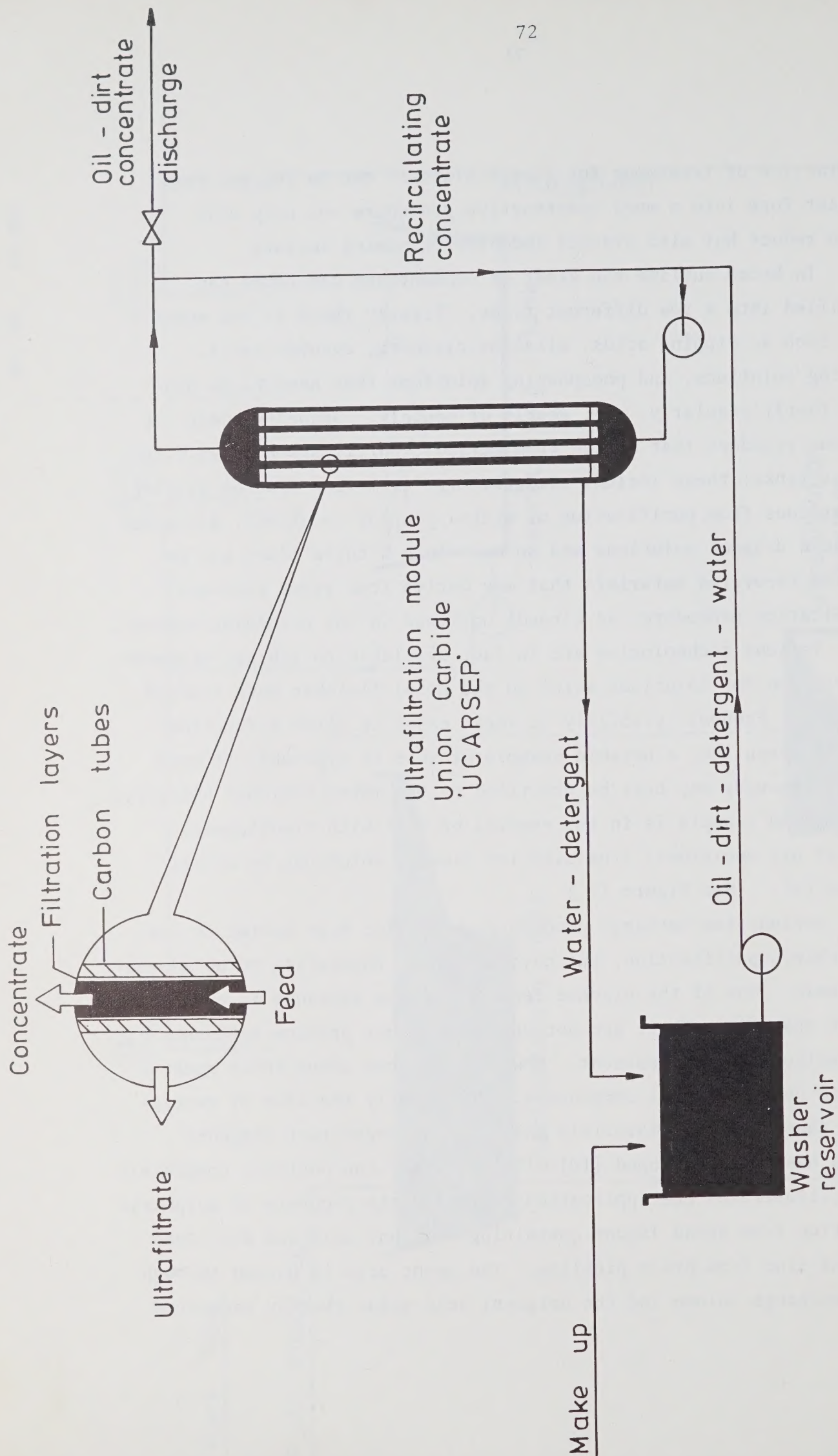


FIGURE 17. TYPICAL OPERATING CONDITIONS IN ULTRAFILTRATION OF ALKALINE CLEANING SOLUTIONS USING UNION CARBIDE CARBON TUBE SYSTEM

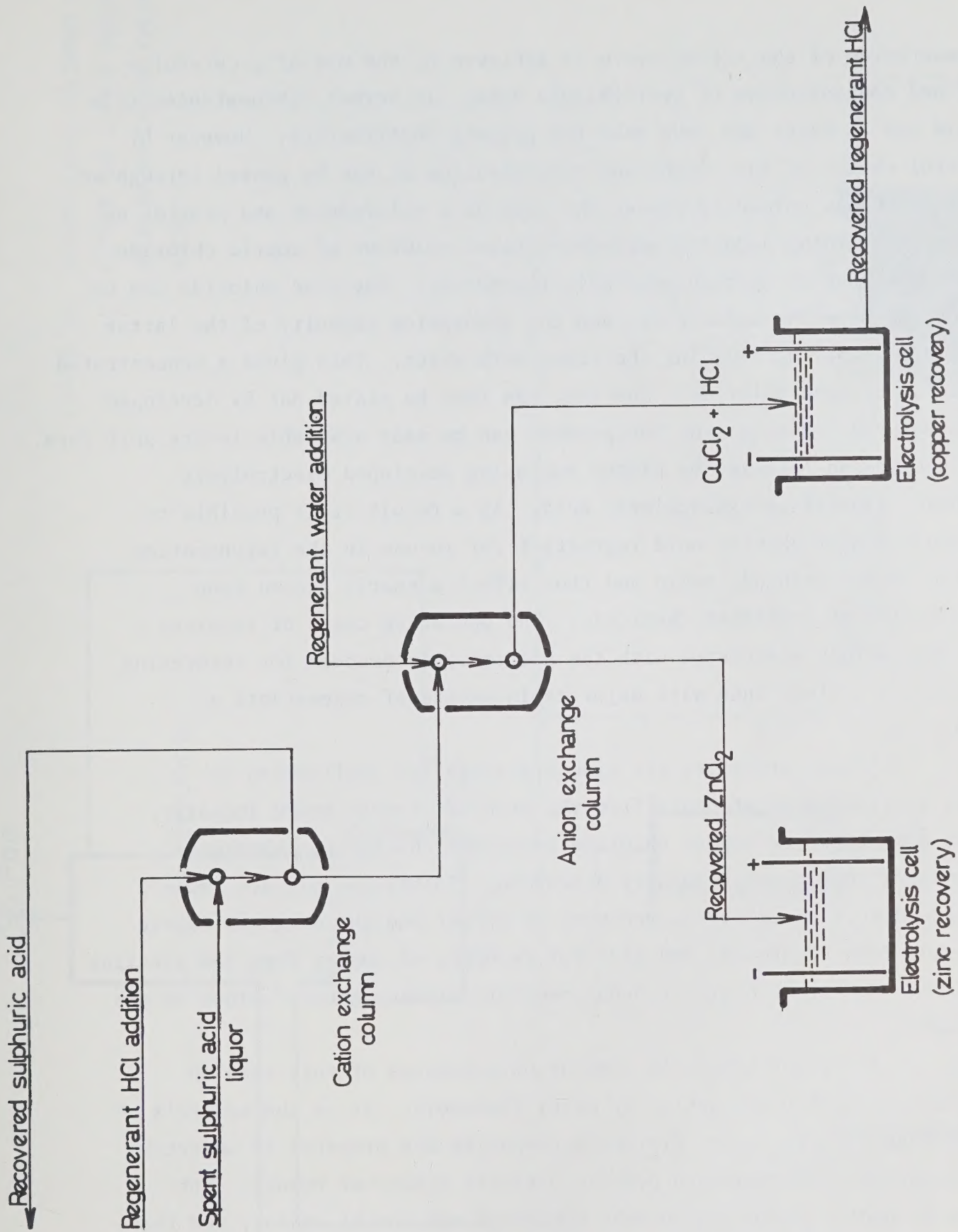


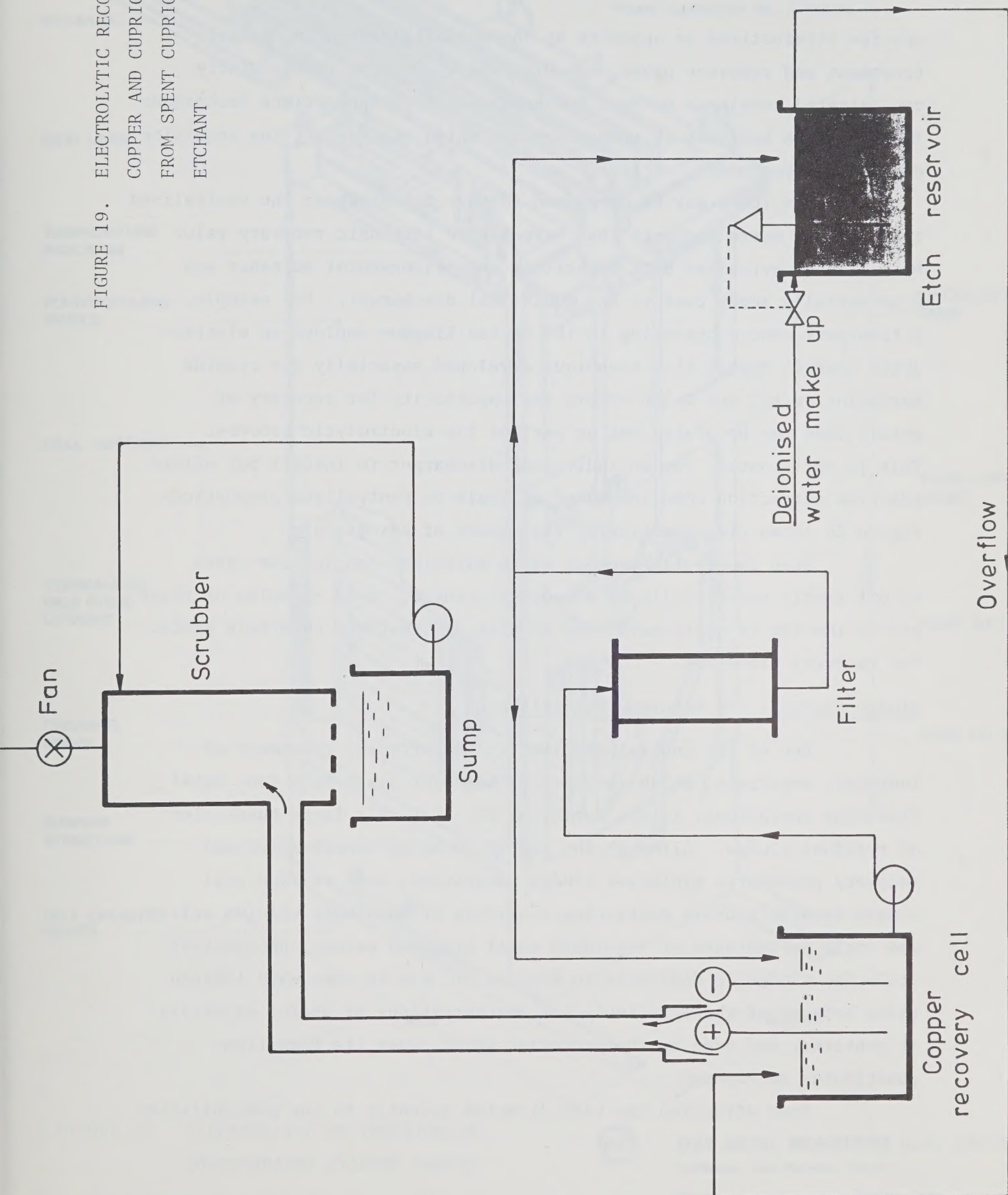
FIGURE 18. RECOVERY OF SULPHURIC ACID, ZINC AND COPPER FROM SPENT BRASS PICKLE LIQUOR BY ION EXCHANGE

Regeneration of the cation resin is achieved by the use of a carefully defined concentration of hydrochloric acid. In normal circumstances this would run to waste and thus make the process unattractive. However by careful choice of the regenerant concentration it can be passed through an anion exchange column to remove the zinc as a chloroanion and provide an eluant containing a relatively concentrated solution of cupric chloride along with excess hydrochloric acid regenerant. The zinc chloride can be recovered from the anion resin and the adsorption capacity of the latter restored simply by flushing the resin with water. This gives a concentrated solution of zinc chloride. The zinc can then be plated out by developed electrolytic techniques or the product can be made available in its salt form. The copper can likewise be plated out using developed electrolysis methods, liberating hydrochloric acid. As a result it is possible to obtain the hydrochloric acid regenerant for re-use in the regeneration of the cation exchange resin and thus effect a nearly closed loop utilisation of treatment chemicals. The operating costs of recovery are thus mainly associated with the electrolysis process for recovering the metals, rather than with major replacements of regenerants as hitherto.

Proven processes are also available for application to recovery from spent etchants from the printed circuit board industry, where ammoniacal or copper chloride solutions containing substantial amounts of copper are regularly discarded. Techniques are available for the direct electrolytic recovery of copper and the original cupric chloride (see Figure 19) and also for recovery of copper from the alkaline types of etchant with simultaneous recovery of the ammonia values in the etchants.

It is worthwhile to comment on processes of this kind in relation to their application by metal finishers. It is the writer's experience that few metal finishing companies are prepared to undertake the extra work necessary to promote ultimate financial reward. Yet there is profit potential in both financial and social senses; and there

FIGURE 19. ELECTROLYTIC RECOVERY OF
COPPER AND CUPRIC CHLORIDE
FROM SPENT CUPRIC CHLORIDE
ETCHANT



are few alternatives as apposite as the establishment of a central treatment and recovery plant, to which waste products (particularly concentrated ones) can be sent for application of appropriate techniques that can be a business in themselves and which can justify the requisite degree of investment.

The theme may be developed further to encompass the centralised treatment of waste products that have little intrinsic recovery value but which nevertheless both constitute an environmental nuisance and a potentially heavy cost to the individual discharger. For example, a treatment centre operating in the United Kingdom employs an electrolytic cyanide destruction technique developed especially for cyanide hardening salts, and which offers the opportunity for recovery of metals that can be plated out as part of the electrolytic process. This is not economic for an individual discharger to install but offers positive attraction when increased in scale to centralised proportions. Figure 20 shows diagrammatically the manner of operation.

Even apparently useless waste materials can in some cases be utilisable beneficially in a recovery centre. Good examples of these are in the use of waste acids and alkalis as treatment chemicals needed for recovery processes.

Sludge Disposal and Recovery Possibilities

One of the central problems in the effluent treatment of inorganic materials, which constitute the major discharges from metal finishing operations, is the formation of relatively large quantities of residual sludge. Although the use of in-house conservation and recovery procedures minimises sludge quantities, some residue will always remain, usually containing a mixture of insoluble calcium salts and small percentages of insoluble metal hydrated oxides, phosphates, etc. The sludge is difficult to dispose of, has in some ways limited value because of the relatively low concentrations of useful materials it contains, and even by the processes which cause its formation constitutes an expense.

Some attention has been directed recently to the possibilities

FLEXIBLE CABLES
TO RECTIFIER

BUSBARS

WEIR LEVEL

TEMPERATURE
INDICATOR

POLYPROPYLENE
PANELS

CELL ASSEMBLY

CORRUGATED
MILD STEEL
CATHODE

GRAPHITE
ANODE

SUPPORT
STRUCTURE

SELF OPERATED
VALVES

1.15m

0.88m

77

5000 ampere, Variable Geometry, CYANIDE DESTRUCTION & METAL RECOVERY Module.

Patent Application No. 31926/73

CIRCULATION
PUMP

FLOW CONTROL
VALVE

PUMP SUCTION

PUMP DELIVERY

2.44m

FIGURE 20. ELECTROLYTIC DESTRUCTION OF
CONCENTRATED CYANIDE WASTES



OXY METAL INDUSTRIES (G.B.) LIMITED.

Purification And Recovery Division

Birmingham.

ENGLAND

of recovering some of the useful metals from these waste sludges. Solvent extraction procedures are a possibility, although their economics have yet to be justified. Another alternative that is attractive from the point of view of its simplicity and relatively low capital investment is by use of the ion exchange system discussed above for recovery of acids and metals [10]. It is a fact that many concentrated discharges involve acids such as sulphuric, and if these are collected centrally and mixed with waste sludges it is possible to leach useful metals from the waste, and then to apply extensions of the metal recovery procedures already indicated. The important aspect of this approach is that, because it conserves regenerant and makes use of co-available waste chemicals, it should be intrinsically economic in operation. Even by the act of concentrating the materials relatively cheaply it presents an opportunity for further purification and separation by more orthodox means. One possibility is indicated in Figure 21 where the input contains a mixture of metals that require both concentration and some degree of separation.

CONCLUSIONS

It is apparent that if both pollution control and economic restrictions are to co-exist then some legislative attention will have to be paid to the wider use of recovery technologies. The nature of the discharges from metal finishing processes is such that rinses need to be treated in-house, but that concentrated discharges can be handled elsewhere at suitably equipped and operated treatment centres. By careful attention to design and operation of these plants the overall pollution problem can be reduced and the recovery operations more extensively applied advantageously than has so far been in many cases realised. Economic considerations apart, there is a great social and environmental advantage in having a small number of well-managed centralised installations where pollution risks can be minimised, over the present haphazard dumping arrangements.

The problem and the opportunity with concentrates points to the need for more encouragement of treatment and recovery centres.

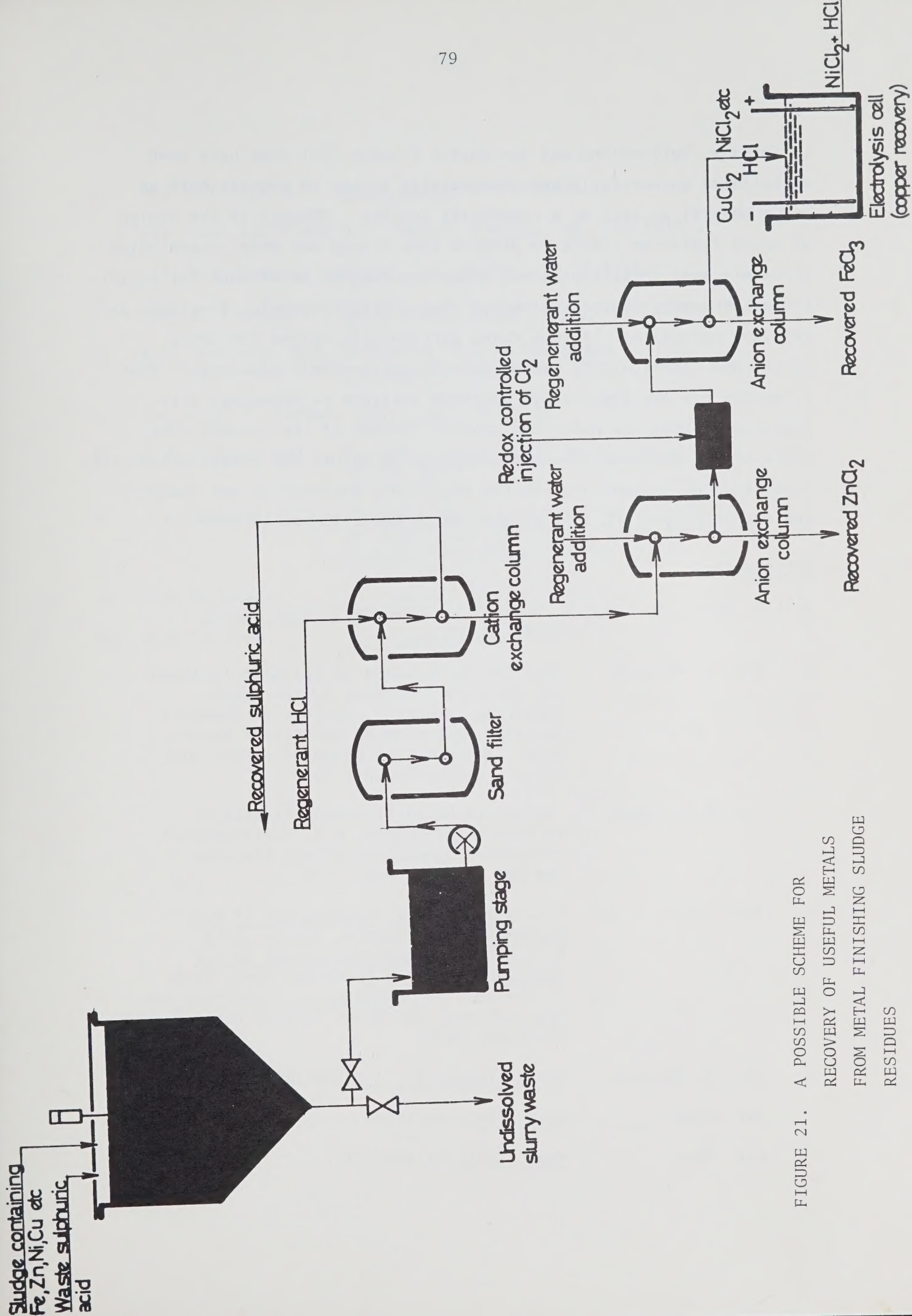


FIGURE 21. A POSSIBLE SCHEME FOR
RECOVERY OF USEFUL METALS
FROM METAL FINISHING SLUDGE
RESIDUES

In Germany, Switzerland and the United Kingdom [11] they have been established successfully and commercially viably to provide both an environmental as well as a commercial service. Changes in the design of metal finishing plants to produce less rinses and more concentrated effluents must certainly direct attention towards techniques for purification of process solutions rather than simple disposal. Treatment and recovery centres are in some cases particularly suited for these operations, particularly where scale has an economic advantage. What is needed now are legislative patterns designed to encourage this positive approach to pollution control instead of the present ones, which are in the main merely restrictive in nature and always potentially productive of schisms between the regulatory authorities and industry; and one only needs to look to the USA to see evidence of this.

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PANEL DISCUSSION

Chairman: Mr. D.T. Duyck

Panelists: Mr. R.A. Abbott, Dr. G. Mattock and Dr. L. Buffa

QUESTION - Mr. P.M. Higgins, Environment Canada:

We are all concerned about metal accumulation in sludges applied to agricultural land and upsets in treatment plant operation that might occur when spent baths are discharged to a sewer system. Being aware of the Ministry of the Environment's encouragement of the establishment of sewer use by-laws by the municipalities and in particular having in mind the possible damage to sewage treatment systems run by the Ministry of the Environment, perhaps I could ask Mr. Abbott to comment a little about the approach the Ministry is taking in providing guidance and advice to municipalities in the matter of developing their sewer use by-laws, and the kind of things that in his mind would be of concern to municipalities and to the Ministry in ensuring that the plants owned by the Ministry in fact are not subject to shock loading.

Mr. Abbott: Our approach to the problem of municipal treatment of industrial wastes, generally, has been to encourage the municipalities to pass and enforce effective sewer use by-laws which limit the degree of discharge of potentially hazardous materials into sewage systems which may have an adverse effect on the treatment process.

We are faced at this particular time, I think, with the prospect that municipal control may not be sufficiently effective to reduce levels of metals in the sludge. The options that are open are: to reduce the inputs of metals into municipal sewage systems, and to control and restrict the utilization of sewage sludge on agricultural land.

It will be necessary to examine both of these alternatives in individual cases. In the instance of Metro Toronto which uses sludge filtration and incineration there is not likely an impact on agriculture, but there may be an impact on atmospheric pollution.

At the other end of the scale are some situations where the sludges have rather high metal content and the sludge is normally distri-

buted onto agricultural land. This is an area not yet resolved in the specific instances. It is probable that industry will be required to reduce its input of heavy metals.

QUESTION - Mr. Higgins:

Would Dr. Mattock care to comment on metals in municipal waste systems in the United Kingdom?

Dr. Mattock: It is necessary to review the question of the acceptance of metals by a municipal sewage system in the context of the percentage of industrial load which must be accepted. There is also a trend to define discharge limits as a function of the local conditions. For example, where there is a high proportion of industrial waste, some are known to be as high as 50-70%, being discharged into the municipal system, it is necessary to apply more strict standards. On the other hand, where the percentage is small even though the total metal loading is large, the problem is less significant.

Mr. Abbott's figures are similar to those found in the United Kingdom. The residual problem of what happens to the metal bearing sludges remains and is more serious than was once considered. There is an increasing tendency for sewage plants to dispose of sludge to agricultural land thus causing increasing concern. Therefore, there has been an increasing stringency in the discharge limits applying to metals.

It is not just a technical problem, but extends well outside the treatment process. Most municipal treatment systems in the United Kingdom use secondary treatment and there are some with tertiary where a greater refinement may be obtained and where there is also some adsorption of metals. The general approach in the United Kingdom is to limit metal discharges. In some cases the limits are less than those mentioned by Dr. Buffa, while in others they are much more restrictive.

QUESTION - Dr. Silveston:

In view of the worry in past years on the part of the Ministry, about the toxic effect of metal contaminants on the performance of a municipal treatment system, has the Ministry collected data on what metal concentration a treatment plant can stand and continue to operate effectively so that the plant could be used as a treatment facility in the removal of heavy metals?

Mr. Abbott: In laboratory studies by the Ministry both individually and collectively, it is my impression that the concentrations which cause significant adverse effects on municipal treatment processes are an order of magnitude or several orders of magnitude higher than the typical levels that are received in raw sewage. I don't think that we get into situations where we have very many identifiable treatment process malfunctions arising from metal discharges. That is not to say that it has not occurred, since it does occur, but generally in situations where five times the typical value of influent concentration of certain types of metals is experienced.

On the other side of that issue, there is some indication that certain specific metals to have a more pronounced effect on sewage treatment processes than others. In this context, hexavalent chromium has been identified as an acute toxicant in the sewage treatment processes and copper has been identified as a potential interference with secondary sludge digestion processes. But, in general, based on operating experience, we don't get the kind of pronounced upsets that you experience if you dose sewage treatment processes or model sewage treatment process units in a laboratory with relatively high concentrations of metals.

QUESTION - Dr. Silveston:

Your discussion primarily concerned the shock load experiments that had been done in the laboratory. My question really pertained to the effect of continuous dosage.

Mr. Abbott: Continuous dose studies on certain individual metals have also been done. The one that comes to mind was an experiment that was conducted about a year and a half to two years ago on the effect of chromium and that was done in a continuous flow, activated sludge model unit which was dosed with concentrations up to 25 mg/l of chromium. The effect of chromium at those concentrations was initially to enhance the treatment process because it tended to act as a primary coagulant, while subsequently it upset the process between the levels of 10 to 15 mg/l. In the context of the concentrations that are typically received at sewage treatment plants, we are talking of concentrations of maybe 2-3 mg/l.

Dr. Mattock: I think that this is very important so far as the percentage industrial waste is concerned in relation to the total sewage flows. I know of a case in England where some years ago there were two or three plants discharging into a small sewage works which was actually operating, not activated sludge, but a percolating filter system. Those flows constituted something like 50% of the total. Of those three plants, one was discharging chromium continuously, but in concentration terms in a rather irregular way by virtue of the manner of the discharges. These concentrations were of the order of 10 or 20 mg/l and sometimes they went up to 50 mg/l.

With full operation of those plants over a period of time, those percolating filters developed the most delicious green slime which eventually deactivated the system altogether. It was a major exercise to get them back on stream again. Of course, those concentrations would not have been significant if the percentage going in was 5% or 10%. It's far different.

Another example is where you can have an effect on the secondary process, again from concentrates. I know of a case where a heavy discharge of zinc hydroxide went down. The reason it went down was because the discharger, with an orthodox chemical treatment plant, had allowed his settlement tank to fill up with zinc hydroxide which flashed over in a very very strong way, a very concentrated way, in a slug form. It got into the sludge at the sewage works, which employed a methane production system. That methane production system was entirely deactivated for three weeks. This again was a case of a slug discharge accidentally deriving from a continuous treatment plant.

I think this exemplifies two cases of discontinuous discharge and continuous discharge where you have to identify what the relationship is of the industrial discharges to the total discharges.

QUESTION to Dr. Mattock:

Does England have any central cyanide destruction plants, and would you comment on their operation?

Dr. Mattock: There are two or three operated in various parts of England by different companies. One uses the electrolytic system mentioned in my paper. This company has switched from chlorination treatment on an

economic basis. Common practice in England, Germany, Switzerland and Sweden is for various companies to accept concentrates including cyanides. In some cases in the past, they have been taken out to sea and dumped. This method is not exactly favoured nowadays, although not as ecologically serious as is sometimes claimed.

QUESTION:

Would you comment on the possibility of cyanide removal in a municipal treatment plant and its effect on the plant? Is this treatment part of the sewage water or is the cyanide carted in separately?

Dr. Mattock: The operation of cyanide destruction is being done by private companies having no connection with a sewage plant. In the United Kingdom, sewage authorities very rarely accept toxic concentrates; they only accept sludges. Therefore, cyanide destruction must be done by private companies or in-house. Cyanides are accepted where there is a continuous dilute flow and the concentration must be within the limits of the particular authority. This depends on the size of the sewer and the ratio of industrial to domestic flow. All evidence indicates that a biological treatment system can acclimate itself to a constant concentration of cyanides. In practice, however, one does not have that uniformity, so it is not practicable to handle cyanides beyond a very low concentration in a biological treatment plant.

In Switzerland many towns are building plants to accept industrial concentrates rather than run the risk of illegal dumps. For example, in one town with a high proportion of metal finishing, officials are planning to erect a plant specifically for such discharges. Geneva has a similar plant.

QUESTION to Mr. Abbott:

Is Ontario planning anything similar? It would appear that Ontario has done relatively little to encourage private industry to set up plants to receive concentrated waste from the metal finishing industry. Are there any plants handling cyanide?

Mr. Abbott: Tricil offers incineration, collection and transportation to a disposal site in Sarnia. I cannot speak precisely for Tricil. Tricil has received assistance from the Ontario Government in land assembly, and

has endorsed the concept of a central control facility for concentrated wastes. The Province probably is not likely to give more than moral support at this stage because of spending constraints.

QUESTION:

What does Mr. Abbott suggest the metal finishing industry do to get something moving on this subject?

Either the Government puts in a relatively cheap plant to handle the whole area or each company puts in individual treatment at a total cost perhaps 10 times higher.

Mr. Abbott: I entirely agree. It is my feeling that the crux of the situation is the handling of the concentrates generated by treatment systems and the concentrate disposal which is inherent in the metal finishing business. We have not received the support of the executive of Government to provide funds for this area.

Questioner: Then, the only solution is organised political lobbying in order to get what is needed.

Mr. Abbott: Draw your own conclusions.

Mr. Davieux, Tricil: Plating wastes are collected at Mississauga for transportation and treatment at Sarnia for disposal. This is done under license from the Ontario Ministry. The company is committed to recycling and recovery. One concern is that there must be legislation and enforcement to justify the financial investment in facilities for treatment or recycling or recovery by private enterprise. Tricil is willing and anxious to work with the Ministry in any endeavour along these lines.

QUESTION:

There is no treatment plant in Mississauga. Is there a plan to have a plant there at a latter date if the volume warrants it?

ANSWER - Mr. Davieux: Yes. We are looking at it at the present time. The Mississauga facility is only a transshipment station to facilitate collection in the Metro area.

QUESTION:

What is the threshold of total cyanide in a water body, particularly heavy metal complexes, rather than the free oxidisable cyanide? What kind of regulation is there in Canada on this form of cyanide?

Mr. Abbott: I am not aware of any recognized water quality standard. I would think that the assessment of a threshold for free and complex cyanide would be on the basis of a bioassay examination, i.e. an acute toxicity test. The conventional 96-hour exposure, by extrapolation, can come up with an acceptable water quality standard in a receiving water. That is really the territory of the biological authorities in Fisheries and Marine Services.

QUESTION - Mr. D. Hutton:

Are either of the governments considering setting up a central agency to establish the possibility of a waste exchange system?

Mr. Abbott: I frankly don't know. There are programs in the municipal solid waste field but not directed at this time toward industrial wastes.

QUESTION to Mr. Abbott:

Does the provincial government permit dried metal hydroxides to be dumped onto municipal land fill sites?

Mr. Abbott: I think it is acceptable provided they are dewatered to substantially dewatered. I think the objection has been raised towards the disposal of liquid sludges or semi-liquid sludges in that context.

QUESTION:

Is it possible that someone could mix iron with cyanide and let it go down the drain?

Mr. Abbott: If the question is based on the assumption that complexed cyanide is less hazardous than free cyanide, then the answer is that that assessment has not yet been made on this subject. We don't differentiate between the two; we work on the basis of total cyanide.

QUESTION:

And the federal government does the same, I assume?

Dr. Buffa: The issue is still open.

QUESTION:

Is there any development in England on that subject?

Dr. Mattock: A very thorny subject. It goes back in the first instance to the analytical methods used. There is in Europe an example of authorities using the silver nitrate precipitation method where accuracy is ± 5 mg/l and they were objecting to effluents where their results were indicating 5 mg/l of cyanide present. On complaint, the authorities simply stated that they must use this test since it was the legal norm.

It is thus necessary to clearly define test methods to be used as a legal arbitration and to be certain that they are adequate before setting effluent limits. Some more sophisticated authorities differentiate between cyanide oxidisable by chlorine and that complexed by iron. It is usually more relaxed in the latter case, but still rigid because the complexed cyanide discharged to rivers may break down in the water body by photo-chemical decomposition. However, there is certainly a differentiation between the two.

QUESTION:

What happens if the crew on central treatment go on strike?

Dr. Mattock: You approach another central facility of which there are now a number in England. In Ontario, where central plants do not exist you will find that once there is legislation, there will be reason for development of facilities.

QUESTION to Dr. Buffa:

Please explain the difference between guidelines and regulations. What can be expected to come in these areas in the next 5-10 years?

Dr. Buffa: A regulation is a rule or an order prescribed by authority. It is a law.

A guideline is an expression of policy. It is used to indicate intentions. It is explanatory or a code of practice.

In order to clarify matters, I will make a hypothetical case. When certain plants are under regulations, it will mean that they are authorized by law to deposit a certain amount of, for instance, a certain metal. From a legal point of view, to prove a violation of the law it will be enough to measure the amount of metal deposited. If it is above the level prescribed, automatically the law is violated. It will be up to the Crown to decide to prosecute.

If you have a guideline under the same circumstances, it means that your discharge is accepted up to a certain value. If a company exceeds that value, it would be up to the Crown to prove that a substance deleterious to fish has been deposited in the water.

The Crown would take a portion of the effluent and carry out an acute toxicity test to determine the effect on fish. It could then prosecute the company if a substance deleterious to fish was indicated.

The comment that guidelines are guidelines and a company shouldn't have to worry about them that I have heard several times has this potential difficulty for the company: the proposed guideline figures quoted in my paper are still 10 times higher than fish can stand, so that if the agencies were to use the toxicity test to enforce guidelines, it would be a powerful tool. This is not to sound threatening, but guidelines could be enforced in this way.

QUESTION:

What is the time frame and process for applying these regulations and guidelines?

Dr. Buffa: It is still very much under discussion and will be analysed again by the Task Force when reconvened early in 1976. Probably gradual implementation of regulations and guidelines for both existing and new plants will be set out. It will depend in part on the availability of central treatment facilities. It is a complicated picture involving cost, etc.

I am confident that over a few years guidelines will turn into regulations, at least for new plants.

QUESTION:

When will dumping come under regulations?

Dr. Buffa: There is no date yet in mind.

QUESTION:

Is there a definite plan in mind to start with the control of dumping?

Dr. Buffa: Yes. We have found that, if our present information is correct, you can control up to 70% of the problems by avoiding off-shift dumping. Thus, that much of the problem is overcome by stopping the practice. That prohibition, combined with bringing concentrates in rinses from 10-15 mg/l down to $1\frac{1}{2}$ -2 mg/l, will reduce the total problem by 95-96%.

Thus, I would like to see the dumping regulation implemented first, followed by gradual introduction of the guidelines for effective limits.

QUESTION to Mr. Abbott:

When a company hauls away waste, who is responsible for it? Are there any regulations which remove the responsibility from the finishing company and put it on the hauling company? Is it a shared responsibility? Would it be left in the courts?

Mr. Abbott: One would have to get a legal opinion. There are ways of developing a contractual arrangement between originator and hauling contractor which would place responsibility on the hauler. There are overriding circumstances which would implicate the originator of the material, e.g. if he did not advise the hauler of the hazard that might be involved in handling the material. Analogies are available in the handling of radioactive waste in which the originator is not permitted to divest himself entirely of the responsibility if he contracts for disposal.

In a simple case the Ministry would be on your backs if there were a problem associated with a waste which originated at your facilities.

QUESTION to Dr. Buffa:

Are we to expect two sets of guidelines? What kind of difference would there be? Would old plants and new plants be treated differently?

Dr. Buffa: One set of guidelines is presently being planned covering existing and new plants.

QUESTION:

Is there a distinction between discharges to oceans and rivers.

Dr. Buffa: No.

QUESTION to Dr. Buffa - Mr. Sabanski, Tricil:

You stated that regulations under the Fisheries Act will come into effect and the destruction of water will be regulated according. Will this new regulation supersede existing municipal or provincial regulations?

Dr. Buffa: I will answer indirectly. Federal regulations apply to discharges to all receiving waters. They may superimpose requirements on provincial legislation but both will be applicable. Policies have not been defined as far as municipalities are concerned.

Mr. Sabanski: Who will be responsible for enforcement of these new regulations?

Dr. Buffa: In provinces where the administration of the Fisheries Act has been delegated to provincial authorities, they will administer the act. In provinces where this delegation has not been given, the federal government, specifically the Environmental Protection Service, will enforce the act.

Mr. Sabanski: Tricil is concerned about the lack of enforcement of the present provincial regulations. We wonder if the same lack of enforcement will be followed under this new federal regulation?

Dr. Buffa: You will have to wait and see.

Mr. Sabanski: My question is how long are we going to wait? As my regional manager indicated, we are in the process of developing a new inorganic treatment facility, but we want to know if the government will enforce the act before we invest the money.

Dr. Buffa: I think you should assume that the development of regulations is done with enforcement in mind. This has been proven in other areas. In the case of the metal finishing, especially as related to discharges to municipalities, the picture at this time is rather complicated.

Mr. Sabanski: Earlier you stated that in the new act the generator of waste will be responsible for reporting his waste streams and ultimately where they are disposed of. How is it your intention to follow that up to ensure that they are in fact being accurately reported?

Dr. Buffa: Firstly, you do not have a new act. The Fisheries Act is in existence. What is proposed are regulations under this act. In the case of the reporting procedures, we believe that every plant should keep records of the way they dispose of their concentrated wastes. Whether we will ask for companies to send such records to any agency or to keep them available for inspection has not been decided. It is intended that the law will require each company to keep a record of the final destination of their waste.

Mr. Sabanski: Present statutes such as Section 33-8 of the Environmental Protection Act require that is to be done. Every generator of waste in the Province of Ontario must be able to account for his waste and where it goes.

Dr. Buffa: Yes, but the federal regulations don't just apply to Ontario but across Canada as well. In this case you would have a duplication in Ontario.

Mr. Sabanski: This will be enforced?

Dr. Buffa: Certainly it will be enforced. We wish to see companies keeping records.

Mr. Sabanski: What about the waste hauler that picks up waste indicating he will take it to a waste disposal site, yet the material never gets there? How will you account for that? This is a common practice in

Ontario now. I would like to hear now how you intend to cope with it under the Fisheries Act?

Dr. Buffa: We have not yet analysed the practicalities of enforcement. We will go through that in the next meeting of the Task Force, but we are establishing the principle of each plant keeping a record of its own waste.

Mr. Sabanski: What time period are we talking about?

Dr. Buffa: At the beginning of this year, I had a deadline for the end of the year, but priorities have changed. I would like to finish this by the end of 1976.

Mr. Sabanski: At the present time, the waste is winding up in the sewers, waste treatment plants, and water courses and it has been happening for years.

Dr. Buffa: That is right.

Mr. Sabanski: You are talking about the end of 1976 before any enforcement is made?

Dr. Buffa: That is a good objective.

QUESTION - Mr. R. Luscombe, Ellis Love & Associates:

The guidelines will be based on mg/l. What incentives are you contemplating for people in the metal finishing industry to carry out recovery and recycling, thus decreasing their volume of water and loading into a receiving stream or sanitary sewer. As I understand the guidelines, there is no such incentive - we should be looking at loadings instead of concentrations. Would an operator who decreases his total loading not be under penalty to carry out such reductions?

Secondly, do you anticipate that you will get into fish toxicity testing with respect to the metal finishing industry or will you use it as a guideline and have biologists assess concentrations? Why acute toxicity? Why not 24-hour static etc.?

Dr. Buffa: We are contemplating additional work in 1976 on toxicity of effluents in the metal finishing industry. The objective of E.P.S. is

production of non-toxic effluents. We will work in that direction even though we realize it may not be achieved at once.

It is our policy to carry out toxicity testing. As for incentives to decrease flows, I don't see any incentive to increase flows, thus requiring a larger treatment plant. It is built into the system that reducing flows while removing metals reduces cost.

Mr. Duyck: Your present system indicates concentration rather than lb/day.

Dr. Buffa: You have witnessed a long discussion south of the border in favour of the opposite. The entire metal finishing industry there has been saying it is impossible and that it cannot be done. In considering that argument, we found valid points. I found valid points in the use of lb/area of surface finished and valid points for the use of concentration.

It appeared clear that in Canada we could not go the avenue of lb/surface area finished. When this alternative was presented to the Task Force, the representatives of the plating industry turned it down as impractical. Therefore, we remained with the alternative of concentrations. We have tried to tailor the regulations to the industry and to design new ways of limiting the discharges.

QUESTION:

Does the Ontario Government hold the same view Mr. Abbott? We have heard rumours that some municipalities were going the route of controlling on plated area so that although the federal government might not require it, it may be enforced on the local level.

Mr. Abbott: The debate whether one uses concentration control or lb/square foot is irrelevant in terms of what we are concerned with, which is basically impact on fish, regulations and guidelines under the Fisheries Act, and the concept of recovery or control at the source.

Dr. Mattock: In Europe where a conveyance charge is made, incentives are introduced to reduce total load without regard to the production output of a company. This approach has great attraction and means one does not have to go the the American system.

Mr. Abbott: The concentration numbers discussed earlier, which are still in the proposal stage, we feel cannot be achieved without doing an intelligent job of in-plant control and recovery first. If there are small plants that wish to try to achieve these numbers by dilution, then so be it.

Mr. Duyck: Assuming that the plant today is meeting the parts per million limits that are required, can this plant expect in the next few years that all of a sudden a law will arrive that tells him that he cannot put more than so many pounds of material down the drain which could be less than what he is putting out now?

Mr. Abbott: Not that I know of.

Mr. Duyck: There are no plans in that direction?

Dr. Buffa: None that I am aware of.

QUESTION to Mr. Abbott:

Is there any appeal procedure if a company believes that regulations set by the municipality have been established more rigidly than necessary?

Mr. Abbott: There is appeal against the province through the Environmental Hearing Board, and there are appeal procedures now under development. I am not sure but I doubt whether these appeals would be applicable to a municipal by-law. The onus is on the Ministry of Environment to support its standards by documentation, etc. In some instances, regional government has been given authority to carry out the enforcement of provincial legislation. In these circumstances, I assume they would be subject to the same restraints as the provincial government.

Mr. Duyck: Apparently the regional government of Peel has recently decided to bring down the allowable levels of heavy metals to 1/5 of what it was over the past 10 years and from your discussion earlier one would expect the sewage sludge would absorb these metals reasonably well, and therefore the lowering of this heavy metal content would not have been necessary.

Mr. Abbott: It is frankly a situation that we are trying to get at through negotiations with the Association of City Engineers. We have a liaison with municipal engineers throughout the province and we have in the past encouraged the passage of uniform municipal sewer use by-laws. The problem is that we have not been able to enforce that requirement and in fact many municipalities have passed their own ordinances and their own standards which vary across the province. It is a difficult situation and is something that is under review by the Ministry.

Mr. Duyck: So at this point there is nothing that an industry can do when their regional authority decides to bring down these limits?

Mr. Abbott: I don't think so.

Mr. Duyck: That is very grim.

QUESTION:

There are Ontario limits of 1500 ppm of chlorides for discharge to a sewer. Could you comment on these limits and similarly the limits for sulphate? Are these low limits really necessary?

Mr. Abbott: The basis of that somewhat antique requirement is the concern for sulphate attack or chloride attack on cement. The problem is that it has been interpreted as a general requirement for control on dissolved solids which, in my view, is not justified. We face the situation for example, that it places a burden on those companies that have done an excellent job of in-plant water reclamation. I think it is unreasonable to enforce these levels as stringent standards unless a municipality is faced with a situation where it is actually experiencing attack on sewers or related problems.

Mr. Duyck: This might be a justification for appeal?

Mr. Abbott: Yes.

QUESTION:

Are there any limits on ammonia?

Dr. Buffa: I believe in our discussions we excluded ammonia as a parameter. We had in mind a toxicity test to pick up those parameters not specifically covered in our regulations and guidelines.

Mr. Abbott: There are provincial effluent quality objectives under development. We are trying to assign a concentration limit for ammonia for various categories of industrial discharge which is consistent with practicable control technology.

QUESTION - Mr. L. Smith:

Since it would seem to be well established that destruction of cyanide to the cyanate stage reduces the toxicity by a thousand times, wouldn't it be sufficient for small plants to carry out this one step destruction only? I would also like to know if you are going to issue standard methods of analysis for effluents?

Dr. Buffa: We will be issuing reference methods very shortly. It will not be necessary for companies to use them, but they will be used as a reference in case of disagreement. These methods will be published along with the regulations and guidelines.

With regard to the oxidation of cyanide to cyanate, we have to crystallize our thinking on oxidizable cyanide versus total cyanide. We will be discussing this at our next meeting of the Task Force.

Mr. Duyck: But this does not apply to sewage treatment plants?

Mr. Abbott: There are grounds for rational assessment of the impact of cyanate on the sewage treatment process. There must be some flexibility about situations where cyanate is oxidizable by the secondary biological treatment process and is at a level that does not impair the operation of that treatment process.

All of the discussion that has gone on right now that has preceded this is really involved in the mechanics and implementation of federal regulations and guidelines and as far as the Province of Ontario is concerned that is something that we have yet to finalize with Environment Canada. As Dr. Buffa has mentioned, the proposals are still under discussion in terms of actual numbers and the implementation of these

things and the integration of them into provincial programs is something that will be negotiated.

For the federal regulations and guidelines for the petroleum refining industry, we have in effect adopted the federal standards and we have superimposed provincial ones on them. In my view, this has worked out reasonably well. We have negotiated schedules of compliance with individual refineries in the province that meet provincial and federal objectives. The difficulty frankly is that we can, from a practical standpoint, do that for seven Ontario oil refineries. We are reluctant to get involved in the bureaucracy that is involved in doing that for 200-300 metal finishing plants.

QUESTION - Mr. Kucharski, Environment Canada:

What minimum concentration of cyanide permits profitable use of electrolytic destruction methods? Secondly, when is it economically possible to use the evaporative recovery system as described and, similarly, with reverse osmosis, and when might they be combined?

Dr. Mattock: In general, the more concentrated the cyanide solution, the more efficient the electrolytic destruction system. There is a strange doubling effect at certain concentrations at approximately one percent as cyanide. You can economically operate with proper control of current density down to 1,000 mg/l. You can still operate down to 100 mg/l but it is no longer economic. It is still possible to remove cyanide at 25 mg/l. The economics, of course, depend on the cost of energy versus the cost of chemicals. In general, I would say, you would use or would review the possibility of using electrolytic destruction methods at concentrations of 1,000 mg/l or higher.

The matter of evaporation and reverse osmosis is slightly more complicated and has much to do with the cost of energy. Where sufficient counterflow rinsing is available to minimize flows and to concentrate the rinses, evaporative methods will probably be the choice. Where physical restrictions such as an existing automatic plating machine limit the flow reduction, then reverse osmosis should be considered, provided that the available membranes make it practical and will accept the solution.

It should be noted, however, that the degree of concentration possible by reverse osmosis will not produce a concentration equal to the original bath concentration. For a reverse osmosis system to accept higher concentrations of rinse waters would require prohibitively high pump pressures.

The Japanese have worked on a combination of using reverse osmosis and evaporation. The preliminary concentration of the rinses is carried out by using reverse osmosis and then standard evaporation is used to concentrate the remaining solution to bath levels. So this approach is a rather heavy-handed way of going about it and I would recommend very careful attention to in-house proceedings before undertaking the very expensive capital and operation costs that would be involved in running these two together.

QUESTION:

Has reverse osmosis been used on final mixed effluent and what has been done to prevent plugging of the membranes with hydroxides or as a result of pH control measures?

Dr. Mattock: Reverse osmosis has been used to treat final rinses after conventional chemical treatment. This seems to be a cockeyed way of going about it. You should have a look at the total problem first and not apply reverse osmosis at the end. Reverse osmosis requires use of sand filtration after settling before presenting the effluent to the membrane and one must be careful that the pH is close to neutral. This seems to be heavy-handed and there are usually better ways. It is comparable to putting everything through reverse osmosis and ending up with a filthy concentrate that still has to be treated, even though you have little water back.

QUESTION - Mr. Coulter, Consultant:

Platers have some objection to too much recovery because their baths tend to become contaminated too fast. They are, however, reasonably successful in controlling most baths by purification procedures, but chromium is a problem because of the difficulty in removing the impurities. Have you any experience that would indicate that the problem of contamination of the chrome bath can be overcome and secondly are there any other baths that cause operational problems when recovery is good?

Dr. Mattock: We have conducted a theoretical analysis, as far as you can be theoretical about these things, on what equilibrium concentrations you may expect from a number of very typical systems and we have compared these with what has been found in practice. This applies in various countries. It is the experience we have had in the United States and in Japan that is significant. The interesting thing is, that in contrast to what we would have expected theoretically, we have succeeded in maintaining a pretty effective stability in the solution and, therefore, in the process operation for a longer period than would have been calculated by our numbers. We haven't quite explained this. Certainly, we have experience in Japan where companies have operated total recovery from chromium by evaporative systems for as much as 18 months to 2 years without any difficulty at all whereas we would have predicted this wouldn't have happened. I think to some extent that there must be other circumstances that we are not aware of that have caused some sort of purification.

One of the other interesting things that we have found when reclaiming nickel, is that it is very important that the rinses before nickel be very clean and, in fact, if possible, it should be deionized water. Indeed, although there is this problem of rinsing nickel plated objects before chromium with deionized water, there are certain advantages so far as the chromium bath is concerned.

We have seen a certain amount of difficulty in the application of evaporators to zinc cyanide systems from carbonate build up which again is not surprising. That is the one where I think there are more problems than in others. Although in Sweden by using a double evaporator system, whereby air was recycled rather than air going into the system with CO_2 in it, it was observed the carbonate build up was less. This in itself I think is a significant observation.

I think the crux of the whole point is that you do not attempt 100% recovery. I would certainly never consider this to be a practical proposition to put forward to metal finishers. I think it is lacking in common sense.

There is a justification for recovery for different reasons.

As a Swedish chap said to me once, I would rather evaporate and recover a concentrate and have no discharge and no problems and reuse as much of

that as I wish than have the risk of pushing things into the sewer and the problems of treatment and all the headaches.

But I must say that where pre-purification of the rinse before the process has been used, and this is generally more important than we often realize, then there have been remarkably few difficulties. Where there have been difficulties, it has been because a few elementary things have been overlooked.

QUESTION to Dr. Mattock:

In 1973 a system was installed in England for the recovery of nickel as nickel carbonate. Could you comment on the present status of that system?

Dr. Mattock: The company initially had a great accumulation of nickel carbonate. For example, as I was saying earlier, this company recovered nickel carbonate but had found it difficult to use because it had an excess over its own requirements. It was having to investigate the alternative of an outlet for that product. The material was reasonably pure, but not of course of a purity that would be acceptable to the normal user of nickel salts. There would have to be some further purification, not very difficult of course, but it meant further operations had to be carried out. This was something of an inhibition to that company. In fact, I think they have overcome this problem because they have found an outlet.

This goes back to the difficulty that if the company produces a product which cannot be reused immediately or cannot be easily resold, it is a very great difficulty for them. I think there is a responsibility when proposing recovery systems that one takes this into account. Metal finishers are not in the recovery business per se.

QUESTION - Mr. Coulter:

Dr. Mattock, to what extent is the potential of inconsistency in the quality of the nickel carbonate recovered limiting its marketability by making the potential purchaser wary of buying the product?

Dr. Mattock: When you recover a secondary product, which is what you are doing when you are recovering nickel carbonate instead of recovering nickel solution for reuse, you are of course liable to have in it contaminants that may be reasonably acceptable to your own process and yet be inimical to another. This means that a company prepared to purchase such a product is going to be somewhat diffident unless the quality of that product and particularly its consistency can be carefully defined.

This, I think, is where the purification idea which may be associated with a centralized treatment-recovery installation has a certain degree of significance. We have been looking at this because we feel that it is a very important part of the chemical cycle within the metal finishing industry. My own view is that the metal finishing supply houses have some responsibility in this matter and that it is in their interests to assist metal finishers who obtain these products as a consequence of recovery programs. I do agree that the nature of the product is something of an inhibition to potential purchasers.

Mr. Coulter: Is nickel carbonate any easier to dispose of than nickel hydroxide? Are you aware of market differences for one or the other?

Dr. Mattock: Basically they are only used in making nickel salts. So, nickel carbonate is easier to precipitate than nickel hydroxide and is more effectively removable. But don't forget that one must filter it effectively. Another trick in precipitating nickel carbonate from metal finishing wastes is to make sure that one uses softened water for the rinses so that you don't get a build up of calcium. This is one of the things where a potential purchaser may have to look rather carefully at the seller's own process activities.

QUESTION - Mr. Martini, James F. McLaren:

Do any of the panel have any experience with the Japanese technique of removing heavy metals from wastewaters by generating magnetic ferrite compounds? I believe that a Japanese company had been set up in Canada with a view to marketing this process.

Mr. Abbott: No.

Dr. Mattock: I have heard of them. That is all.

Mr. Martini: Do any of the smelters or refineries in Europe show any interest in the sludges generated by the metal finishing industry and similarly, to Mr. Abbott, do any of the smelters in Ontario show interest in these materials?

Dr. Mattock: A company in the United Kingdom dealing in nickel does receive some nickel materials and then merely ships it to Canada for purification.

Mr. Abbott: There is no interest in the Canadian refiners in receiving sludges.

Mr. Roesler: Normally, it is not possible to get rid of metal hydroxide sludges. However, in one instance in Germany 10,000 tons of nickel powder or powder containing nickel was to be shipped, some of it to Canada. The powder flowed like water in the ship and in order to pack it down, 2,000 tons of nickel hydroxide was disposed of to mix with this powder and it was then shipped to Sweden and Canada.

QUESTION to Dr. Mattock:

Have you in the United Kingdom found any cheaper method than evaporation for recovering hydrochloric acid from spent pickle liquor containing heavy iron loads?

Dr. Mattock: No. Mostly treatment of spent hydrochloric acid pickle liquor is carried out by some roasting process or other. There is a possibility of recovering hydrochloric acid from pickle liquor containing iron via the anion exchange procedure that I described in my paper. In practice, it only works at a fairly high concentration of hydrochloric acid, i.e. greater than 5 molar.

GEOGRAPHICAL DISTRIBUTION OF METAL FINISHING PLANTS
IN CANADA

by

K.R. Coulter
Consulting Engineer

As a part of the survey conducted by Environment Canada and reported in "Review of the Metal Finishing Industry"* an attempt was made to determine the geographical concentration of the metal finishing industry both in terms of the number of companies and the volume of business being performed.

However, in order to have some appreciation as to the accuracy of the survey and its usefulness, it is necessary to consider the objective of the survey and its limitations.

This survey was carried out in 1973 across Canada using a questionnaire sent to over 1000 companies for the purpose of:

- 1) identifying the companies in Canada with similar effluents;
- 2) identifying final destination of effluents;
- 3) obtaining approximate quantities of contaminants in effluents;
- 4) identifying controls now in place;
- 5) identifying methods of disposal of concentrated wastes; and,
- 6) determining the size and geographical locations of the industry.

* Environmental Protection Service Report EPS 3-WP-75-2

For a variety of reasons the following industries were excluded at this time with the intent of picking them up later:

- 1) automobile manufacturers;
- 2) steel companies other than Stelco;
- 3) founderies;
- 4) wire manufacturers;
- 5) automobile radiator manufacturers;
- 6) battery manufacturers;
- 7) companies with painting being their only metal finishing process; and,
- 8) ferrous and non-ferrous tube manufacturers.

The total listing of companies doing some kind of metal finishing takes in about 7000 firms but with the above exclusions the list of companies was reduced to just over 1000.

The list was compiled from names available from the Ontario Ministry of the Environment, the various regional offices of Environment Canada and a consultant. The distribution and replies to the questionnaire are shown in Table 1.

TABLE 1 SUMMARY OF QUESTIONNAIRES SENT AND REPLIES RECEIVED

	QUESTIONNAIRES MAILED	REPLIES RECEIVED	APPLICABLE
Newfoundland			
Nova Scotia	15	9	4
New Brunswick			
Quebec	272	150	62
Ontario	572	311	217
Manitoba			
Saskatchewan	165	88	28
Alberta			
British Columbia	64	51	30
TOTAL	1088	609	341

The response of 60% has to be considered very satisfactory since replies were not compulsory. In terms of the size of the industry, the companies replying performed over 75% of the metal finishing in Canada, as previously defined.

Of the 609 replies received only 341 were deemed applicable to the survey. Companies that did only mechanical, physical or organic finishing were considered to be non-applicable.

While a complete copy of the questionnaire is in the "Review" it might be helpful to look at some of the questions that were asked and the divisions under which they were asked.

The processes that were looked for are shown in Tables 2 and 3.

Table 4 illustrates the type of questions asked about each of the processes mentioned above and Table 5 indicates the results of answers concerning the number of employees in jobbing operations in each of the chemical processes and electrolytic plating and hardening processes as well as the number in captive operations of both types of processes.

Table 6 shows the receiving body of discharges from these companies but doesn't tell the whole story. In many instances, although as far as the company is concerned it is discharging to a sanitary sewer, in fact the municipality has no treatment system. Most of the companies that failed to report were on some kind of a municipal system.

Table 7 shows the number of installations reporting some kind of wastewater pollution control and Table 8 those with some kind of monitoring. Since nearly all of the companies with treatment systems replied to the survey it is reasonably safe to assume that almost all of the companies which did not reply have no waste treatment. Although the table does not show it, most of the companies with waste treatment are not in large cities.

Since pH control is inherent in all chemical destruction systems it can be seen that only 86 companies out of the 341 have any kind of chemical treatment and only 50-55 have any heavy metals removal, that is 16%.

Tables 9, 10 and 11 show the consumption of the major chemicals consumed by the entire Canadian industry. These approximations were arrived at by applying correction factors to the information obtained from the 341 questionnaires. The questionnaire was designed to make it as simple as possible for company filling it out. As a result only the main chemical in any process was asked for. The consultant added additional chemicals that are normally used with the main chemical, based on standard practice in the industry.

The other correction factor was for the quantities used by companies which did not reply to the survey. Those correction factors are shown in Table 12. They were arrived at by taking the number of employees believed to be in the metal finishing of these missing (but known) companies compared to the number employed by companies doing comparable processes who did report.

The significance of the quantity of consumption, of course, is the amount of it which reaches the effluent stream. Some of it does end up on the product. About 15% of chromic acid will be used to supply the chromium that is plated out. Other metals such as nickel will have some metal deposited from the nickel solution in some instances and in others there may be more metal in the effluent than is attributable to the use of nickel salts.

Most of the chemicals are, however, lost to the wastewater by any of the routes indicated in Table 13. Dumps result from the necessary discharge of spent baths such as alkaline cleaners, acids, chromates and occasionally dichromates, sludges from filter cleanouts, tumbling barrel operations and bath purification procedures. Accidental spillages such as overflows, tank leaks, filter leaks and spills between processes will also enter the effluent stream.

The concentration of the dumps will vary from 5-10% for cleaners and acids 200,000 mg/l for any chromic acid dump that might be made. Metal concentrations in dumps of acids used for bright dipping may be as high as 1000 mg/l.

It is estimated that dumps, spillages, leaks etc. account for up to 70% of the chemicals lost to effluent streams, with most of the balance lost through running rinses. Table 14 shows the quantity of metal and cyanide ion estimated to be lost into wastewater in Canada in 1973.

With some approximation of the total load to the environment in Canada we can now turn to the distribution of this load across the country.

Using a combination of number of employees and consumption of materials the percentage of the industry in each of five regions is shown on Table 15. The distribution of the number of companies within 30 miles of six major urban centers is shown in Table 16.

Most of the industry in Quebec is within the 30 mile range of Montreal, while that of Ontario is more scattered. In southern Ontario, there is a concentration around four urban centres. From a point in the vicinity of Woodstock or Stratford there are a potentially 70 companies within 30 miles and from a location near Tilbury there is a potential of 30 companies.

While the number of companies in Montreal is slightly more than half the number in Toronto, the volume represented by these companies is more in the order of 1/3 of the volume of business in Toronto. The volume of business in Toronto represents 30% of all the business done in Canada, so that Table 17 will approximate the metal load to the environment in the Toronto area. In addition to this loading, of course, are the effluents from the plants excluded from the survey.

In conclusion I would like to comment that I believe the survey of the metal finishing industry was a useful exercise and it established a great deal about the nature of the industry. While it was not intended to reveal financial information about individual companies, some idea of the financial strength could be surmised and this too was of value.

The information given here should only to be considered with the qualifications presented and the limitations that are inherent.

TABLE 2. CHEMICAL PROCESSES

Degreasing	(i) Vapor (ii) Emulsion (iii) Detergent	Phosphating
Pickling		Chromating
De-Rusting		Electroless Copper Plating
Stripping Metal Coatings		Electroless Nickel Plating
Passivating		Bright Dipping
Activating		Hardening
		Other (Specify)

TABLE 3A ELECTROLYTIC PROCESSES

	(i) Vapor	Anodizing	(i) Sulphuric (ii) Chromic
Degreasing	(ii) Emulsion (iii) Detergent	Lead Plating	
Pickling		Copper Plating	(i) Cyanide (ii) Acid
Electrocleaning		Nickel Plating	(i) Bright (ii) Semi-Bright
Etching		Brass Plating	
Chromium Plating		Gold Plating	
Tin Plating		Silver Plating	
Zinc Plating	(i) Cyanide (ii) Non Cyanide	Electropolishing	
Cadmium Plating		Other (Specify)	

TABLE 4. QUESTIONS ASKED WITH QUESTIONNAIRE

Products Processed Per Day (sq. ft. or lb.)
 Maximum Yearly Capacity (sq. ft. or lb.)
 Number Of Process Tanks
 Capacity Of Process Tanks
 Main Chemical Consumed (lb./yr.)
 Number Of Dumps Per Year
 Metal Anodes Consumption (lb./yr.)

TABLE 5. DISTRIBUTION BY EMPLOYEES

Employees In Metal Finishing	Chemical Only	Electrolytic And Cyanide Hardening	Total	Captive
1 - 10	76	113	189	133
11 - 50	28	80	108	73
Over 50	10	34	44	35
Total	114	227	341	241

TABLE 6. WASTEWATER DISCHARGES

To Municipal Sanitary Sewer	218
Other	86
Not Reported	37

TABLE 7. WASTEWATER CONTROL

	Chemical Only	Electrolytic and CN Hardening
pH Control	21	65
Solids Separation	42	92
CN Ion Control	0	54
Chromium Ion Control	9	55
Other Metals Control	9	50
Total Companies Responding to Survey	114	227

TABLE 8. WASTEWATER MONITORING

<u>Monitoring of:</u>	<u>Chemical</u>	<u>Electrolytic and CN Hardening</u>
pH	25	84
CN	1	40
Metals	11	46
Suspended Solids	10	40
Record Keeping	25	81
Authorities Advised	13	49
Total Companies Responding to Survey	114	227

TABLE 9. CONSUMPTION OF CHEMICALS BY THE
METAL FINISHING INDUSTRY (lb/yr)

Cadmium Compounds (Including Cyanides)	25,600
Copper Compounds (Including Cyanides)	445,000
HCl, H ₂ SO ₄ and Other Acids	22,169,000
Chromic Acid And Miscellaneous Chromates	1,719,000
Phosphoric Acid and Miscellaneous Phosphates	4,703,000
Nickel Compounds	1,253,000
Caustic Soda	2,533,000
Other Cyanides	1,161,000
Detergents	2,164,000
Chlorinated Hydrocarbons	5,600,000
Alkali Cleaners	610,000

TABLE 10. CONSUMPTION OF CHEMICALS BY CHROMATING PROCESSES (lb/yr)

Miscellaneous and Trade Name	6,888
Miscellaneous Chromate	137,495
Miscellaneous Dichromate	3,960
Chromic Acid	48,187
Dichromic Acid	482
Nitric Acid	315
Sodium Dichromate	14,385
Potassium Dichromate	8,640

TABLE 11. CONSUMPTION OF CHEMICALS BY PHOSPATING PROCESSES (lb/yr)

Miscellaneous And Trade Name	93,090
Miscellaneous Phosphate	597,698
Nitric Acid	400
Phosphoric Acid	71,880
Iron Phosphate	617,628
Zinc Phosphate	371,578

TABLE 12. CORRECTION FACTORS FOR TOTAL CANADIAN
CHEMICAL CONSUMPTION

Quebec	1.6
Ontario	1.2
Manitoba	1.4
Alberta	1.1

No Correction Factors Were Necessary For The Other Provinces

TABLE 13. CHEMICAL LOSSES

<u>METAL ION</u>	<u>RINSES (lbs)</u>	<u>ACCIDENTS, DUMPS</u>	<u>TOTAL (lbs)</u>
Copper	48,000	146,000	194,700
Nickel	78,000	180,000	258,000
Chromium	314,000	278,000	592,000
Zinc	81,000	108,000	183,000
Cadmium	7,000	9,000	16,000
Cyanide Ion	94,000	220,000	314,000

TABLE 14. METAL AND CYANIDE IONS IN THE WASTE LOAD OF
ELECTROPLATING OPERATIONS IN CANADA

The chart below shows the total metal and cyanide ion loads that can be expected in the effluents from the electroplating industry, based on the consumption of the salts as reported in the survey of the industry.

<u>Metal Ion</u>	<u>Rinses (lbs)</u>	<u>Accidents Etc.</u>	<u>Total (lbs)</u>
Copper	48,000	146,000	194,700
Nickel	78,000	180,000	258,000
Chromium	314,000	278,000	592,000
Zinc	81,500	102,000	183,500
Cadmium	7,000	9,000	16,000
Cyanide Ion	94,000	220,000	314,000

TABLE 15. REGIONAL DISTRIBUTION OF INDUSTRY BY VOLUME
OF BUSINESS

Maritimes	0.5%
Quebec	17%
Ontario	74%
Man. Sask. Alta.	5%
B.C.	3.5%

TABLE 16. COMPANIES WITHIN THIRTY MILE RADIUS OF SIX
MAJOR URBAN CENTERS

<u>CITY</u>	<u>FROM SURVEY</u>	<u>OTHER POTENTIAL</u>	<u>TOTAL</u>
Montreal	60	40	100
Toronto	120	65	185
Kitchener	35	10	45
London	18	4	22
Windsor	10	5	15
Winnipeg	12	10	22
Vancouver	25	3	28

TABLE 17. METAL AND CYANIDE IONS IN THE WASTE LOAD
IN THE TORONTO AREA

<u>METAL ION</u>	<u>RINSES (lbs)</u>	<u>ACCIDENTS, DUMPS</u>	<u>TOTAL (lbs)</u>
Copper	14,000	45,000	59,000
Nickel	23,000	54,000	77,000
Chromium	95,000	80,000	175,000
Zinc	25,000	30,000	55,000
Cadmium	2,000	2,000	4,000
Cyanide Ion	25,000	60,000	85,000

ORGANIZATION AND OPERATION OF CENTRALIZED PLANTS FOR THE TREATMENT OF SPECIAL WASTES FROM THE METAL FINISHING INDUSTRY

by

N. Roesler
Department of Sewage Treatment
Ruhrverband D-43, Essen, Germany

INTRODUCTION

In "Environmental Protection" and, generally, in the "Improvement of Quality of Life", special wastes in the form of gases, liquids, and solids, and even noise are becoming more and more important in comparison with normal municipal sewage and garbage. Although the legal task of the Ruhrverband is the acceptance and treatment of normal municipal wastewater, we found that we were struggling to treat unusual waste components, which, despite federal laws and municipal regulations, entered into the sewers and complicated the treatment of wastewater. The Ruhrverband, therefore, has become concerned with various branches of industry and their liquid wastes since its establishment in 1913. Since about 1960, intensive efforts have been made which have resulted in centralized treatment plants with facilities for treating the wastes coming from pickling and galvanizing industries.

ORGANIZATION

The central Decontaminating Plant, Iserlohn (ZEA-Iserlohn), the first and also the largest plant in West Germany, was completed in 1964. This plant treats metal finishing wastes from an area of 380 km², comprised of the town of Iserlohn and eight municipalities, forming the district of Iserlohn. In this area, there are about 200 installations, in most cases medium-sized industrial enterprises which are running approximately 1000 baths for galvanizing, anodizing and non-ferrous metal pickling, with a total volume of roughly 1000 m³. (See Figure 1)

After obtaining the agreement of all the associates concerned, the Corporation for the Advancement of Industry Ltd., Iserlohn, took over the responsibility for metal finishing waste treatment in this area,

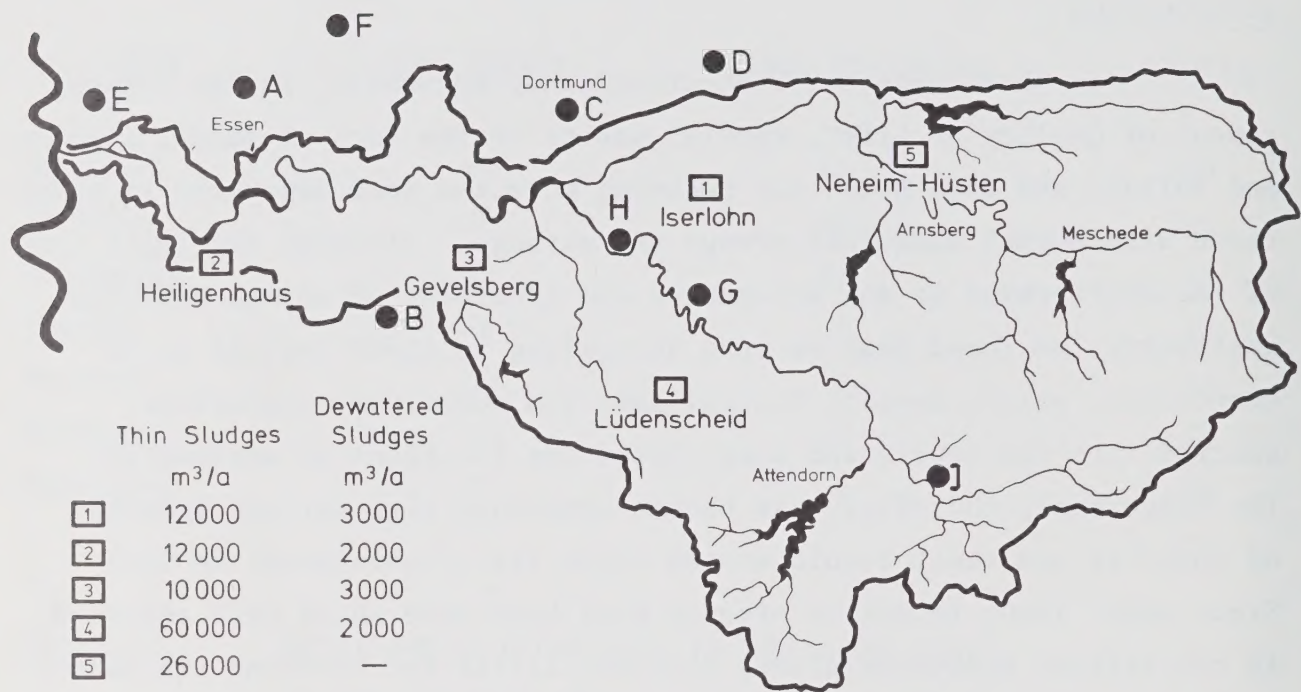


Fig.1 Central Plants for the Treatment of Hydroxide Sludges in the Catchment of the River Ruhr

and charged the Ruhverband for planning, constructing and operating the plant, in accordance with section 3 of the Ruhr Pollution Act (law of the regional government of Northrhine Westfalia).

The ZEA-Iserlohn plant is divided into three sections (Figure 2). The first section comprises the collection tanks, and the cyanide oxidation and chromate reduction facilities. Section two is the neutralization and desludging facility for wastes coming from section one, as well as for acid and alkaline solutions from aluminum-anodizing plants, and iron and non-iron pickling plants. The third section comprises the following steps: thickening, dewatering and disposal of hydroxide sludges coming from section two. It also handles sludges delivered from companies which have pretreated their wastes to the extent they have found economical to do in-house. The ZEA-Iserlohn can, therefore, handle toxic concentrations, thin and thickened sludges, and dewatered sludges requiring disposal. This allows each associate to choose the grade of pretreatment which is most economical for him, and consequently, the cheapest way to dispose of his wastes.

In the case of the second plant, the ZSEA-Heiligenhaus, the responsible authority is the Düsseldorf-Mettmann (Figure 3). The various installations in this area preferred to handle the first and second sections (as described above) of wastewater treatment within their own plants. Hence the Ruhrverband planned and constructed a storage, dewatering and dumping facility for sludges from Heiligenhaus and has been operating since 1968. Unlike the ZEA-Iserlohn, membership is compulsory for all the installations unless one can prove that wastewater discharges from his own plant comply with the law.

A third plant, corresponding in function to the second model above, was planned, constructed and is being run by the district government of Arnsberg for about 100 associate installations. A fourth plant has been constructed by the town of Lüdenscheid and a private garbage collector is running it for another 100 installations.

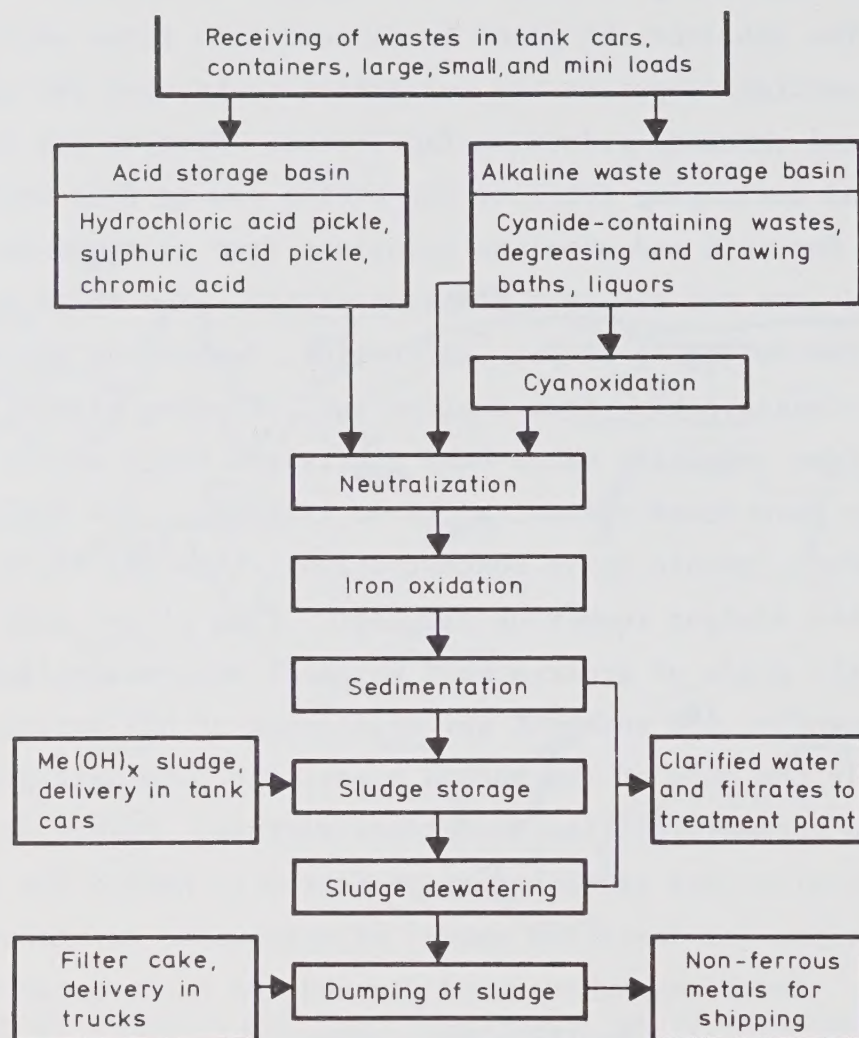


Fig. 2 Schematic diagram of a central plant for the removal of toxic substances from electroplating plants and pickling plants

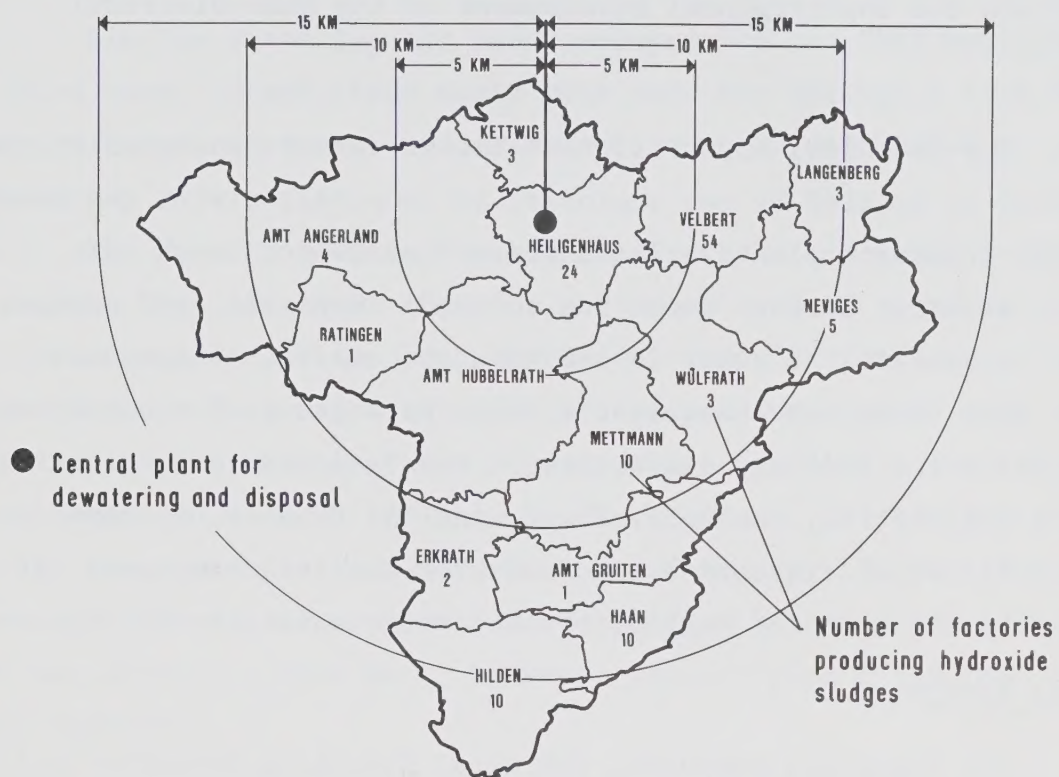


Fig.3 District Düsseldorf-Mettmann
Concentrations of factories in the district

A fifth central plant, corresponding in function to the ZEA-Iserlohn, will be installed in Wuppertal, i.e. outside the catchment area of the Ruhr River. This plant and three others will become the central collection and treatment facilities for all special wastes coming from the metal finishing industry in this area. The responsibility for these installations lies in the hands of the Ruhrsiedlungsverband (Association for Superregional Development of the Ruhr-District).

MANAGING

The technical supervision of the two plants operated by the Ruhrverband is handled by two engineers in cooperation with two nearby wastewater treatment plants. The engineer involved in each case is able to add or withdraw workers according to need. Normally, two workers are required to operate the plant in Iserlohn and one in Heiligenhaus.

The financial management is done by a group of elected men who represent the industry (associates), the responsible corporation, the local authorities, the Ruhrverband, and the Chamber of Commerce. Each year, the financial statements and plans for the following year are presented by the managing engineer to the representatives for approval.

FINANCIAL ASPECTS

For financial purposes, the metal finishing industry (galvanizing, anodizing and pickling factories) in Iserlohn has been separated into three groups according to the volume of their baths, the amount of chemicals bought, the quantity of process water needed, the quantity of sludge produced, and so on. Also taken into account is the degree of participation or the amount of pretreatment carried out by the companies themselves. A small plant wanting to participate in all steps of central treatment may pay, for instance, 5000-DM, while a large company which sends only dewatered sludge for dumping may pay 20,000-DM for the disposal.

In addition, the Ruhrverband has granted a loan of 150,000-DM, the town of Iserlohn a lost subsidy of 50,000-DM and the regional

government another lost subsidy of about 200,000-DM, towards the cost of the Central Plant. The construction costs for the Central Treatment Plant for Iserlohn, including a second filter press and a second dump for about 50,000 m³ totalled 2 million DM. The second filter press and the second sludge depository were paid for from savings on the operating costs.

Similar financing has been arranged for the ZSEA-Heiligenhaus. In a third case, construction costs were paid for through a loan, so that the capital cost, (interest and repayment) must be calculated as part of the operating costs.

The operating costs for the ZEA-Iserlohn are shown in Tables 1, 2, 3 and 4. They are lower than for any other central treatment plant in Western Germany; certain costs have not risen for ten years. An example of the annual calculation of profit and loss can be seen in Table 2, for neutralization, and in Table 3, for sludge handling. The status of special reserves is shown in Table 4. In the past, all necessary expansion programs have been paid for out of the special reserves.

If the capacity allows, waste is also accepted from the so-called non-members. They must, however, pay a higher price than members for the service.

PREPARATION, COLLECTION AND TRANSPORTATION OF THE WASTES

A minimal pretreatment must be carried out by the companies themselves. First, the quantity of rinse water must be reduced through improved rinsing techniques. This can be achieved either by using a still-rinse after the bath and two or three counter current rinses, or by using a more technically advanced method: one still-rinse and one flow-rinse in combination with ion-exchangers (Figures 4 and 5). The first method results in so-called semi-concentrates and lesser quantity of rinse water. These must either be treated in the plant, or stored in a tank until a quantity has been collected which can be economically transported to the central treatment plant.

TABLE 1. CHARGES FOR THE USE OF TWO CENTRALIZED PLANTS FOR REMOVAL OF INDUSTRIAL TOXICANTS, IN DM PER CUBIC METER

	Central detoxification plant Iserlohn *)		ZSEA**) Heiligenhaus	
	1. Construction phase	2. Construction phase		
(Members participating, non-members = not participating in the construction of the installation)	Non-members	members	Non-members	members
Acid and Cr acid semi-concentrate	150,- DM			
Acid and Cr acid concentrate	200,- DM			
Semi-concentrate containing CN	170,- DM			
Concentrate containing CN	247,- DM			
Eluate from ion exchangers	90,- DM			
Acid pickling waste waters		74,50 DM	87,60 DM	
Spend pickling fluid containing sulphuric acid		—	113,80 DM	
Pickling fluid containing = 5 g Cu/l		29,50 DM	52,60 DM	
Pickling fluid containing = 15 g Cu/l		20,- DM	20,- DM	
Dilute sludge ~ 3 % DS		6,55 DM	9,- DM	17,40 DM
Dewateret sludge ~ 30 % DS		12,50 DM	19,50 DM	16,- DM

*) excluding shipping costs and value added tax

**) including shipping costs and value added tax

TABLE 2. RUNNING COSTS FOR CENTRAL NEUTRALIZATION, 1974

<u>Receipts</u>	DM	<u>Expenditures</u>	DM
Neutralization of liquids from		Wages	23.500
11 members	28.900	Chemicals	32.100
		Energy	1.600
about 50 non members	300.500	Costs for sludge handling	80.800
		Maintenance	66.600
		Reserves for maintenance	40.000
		Insurance for risks	20.000
Receipts from liquids sold	600	Technical and administrative supervision	47.400
		Reserves for unforeseen	32.200
Interest for reserves	15.800	Transport costs for concentrates sold	1.600
	<u>345.800</u>		<u>345.800</u>

TABLE 3. RUNNING COSTS FOR SLUDGE HANDLING AND DISPOSAL

<u>Receipts</u>	DM	<u>Expenditures</u>	DM
19 members		Wages	28.800
dewatered sludge	26.600	Chemicals	3.600
thin sludge	11.200	Energy	2.000
non-members		Transport and Disposal	18.000
dewatered sludge	7.800	Reserves for recultivation	15.700
thin sludge	50.300	Maintenance	69.600
costs for special treatment	6.500	Reserves for maintenance	30.000
Hydroxide sludges from central plant (galvanizing industry)	31.200	Insurance for risks	3.200
Hydroxide sludges from central plant (pickling industry)	80.800	Technical and administrative supervision	21.400
Interest for reserves	21.500	Interest for loan	5.200
		Repayment for loan	10.000
		Reserves and unforeseen	28.400
	<u>235.900</u>		<u>235.900</u>

TABLE 4. SUMMARY ON STATUS AND DEVELOPMENT OF SPECIAL RESERVES

<u>Central Neutralization</u>	Status 31.12.73 1967-1973 DM	Withdrawal 1974	Increase 1974	1967-1974
Reserves for maintenance	85.000	- 10.000	+ 40.000	115.000
Reserves for unforeseen	95.900	- 15.000	+ 32.000	112.900
<u>Central Sludge Handling</u>				
Reserves for recultivation	40.700	- 6.700	+ 15.700	49.700
Reserves for maintenance	45.000	-10.000	+ 30.000	65.000
Reserves for repayment of a loan	105.000	—	—	105.000
Reserves for unforeseen	47.700	- 11.200	+ 28.400	64.900
				<u>512.500</u>

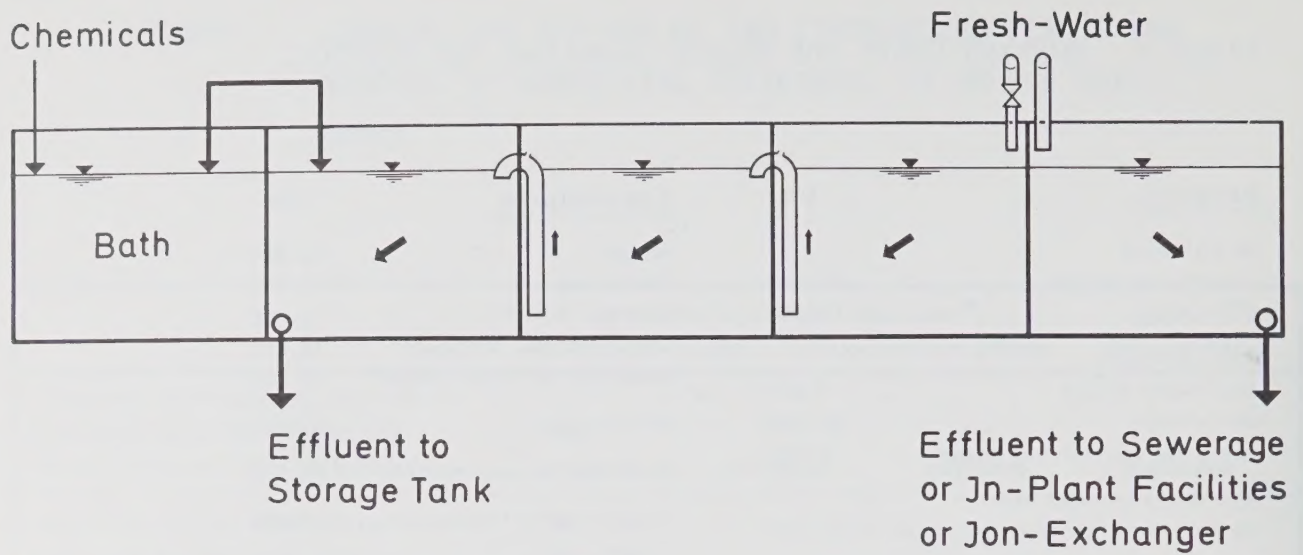


Fig.4 3-Step-Counter-Current Rinse with Flow-Rinse

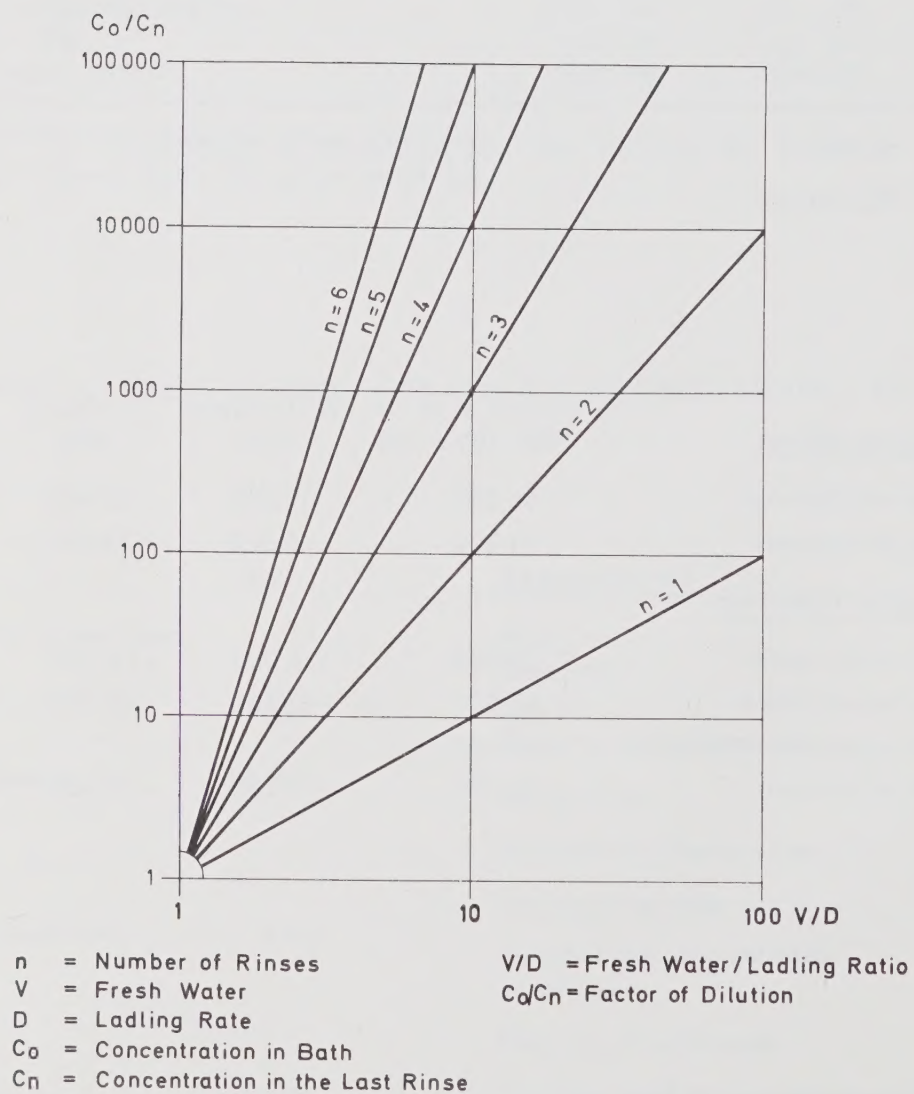


Fig.5 Water Consumption of Counter-Current Rinse

In the second method of still-rinse, flow-rinse and ion-exchangers, a very low quantity of freshwater is needed to make up the losses in the rinsing cycle but different storage tanks must be provided for the acid and alkaline solutions.

For collecting, storing and transporting the liquors, we offer containers of different size (60; 200; 800 liters) without any additional payment. If the quantities are greater, it may be more economical to build some storage tanks in the plant itself and transport by 5-, 10-, or 20-m³ trucks. This is being done, for instance, when thin sludges from in-plant treatment facilities have to be transported once or twice a month to the central treatment plant.

In the case of the central dewatering facility in Heiligenhaus, transport of the wastes from the industrial plants to the facility is handled by one transport company which charges the same price, regardless of the distance involved. This cooperative principle eliminated disagreement about the location of the facility and possible economic disadvantages which may have occurred in transporting the wastes.

OPERATION AND MAINTENANCE - RECOVERY OF LIQUIDS

This paper is not intended to give the chemistry of the oxidation of cyanides, or of the reduction of chromates, or of neutralization. The following section details some of the experiences we have had with our central plants, and the solutions we found to some problems.

We found that one of the most important items was storage capacity. Adequate storage capacity saves on time and expenses for chemicals and, therefore, on operating costs. For instance, when the central plant for Iserlohn was started, we found that a large quantity of NaHSO₄ was required for the reduction of chromates. We began to collect and store iron-chloride and iron-sulphate solutions for use instead of NaHSO₄. This eliminated the need to buy expensive chemicals which, in any case, increased the salt concentration in the effluent. We also store the alkaline solutions we collect, for use in neutralization, as well as in the oxidation of cyanides, as a substitute for sodium hydroxide. Alkaline solutions are also used to dilute concentrates to 1 g CN/l. Certain concentrates, in most cases small quantities, can

also be collected, equalized in quality and be prepared for recycling if storage space is available. We are collecting some hundred m³/year of copper and nickel containing solutions, which are transported in 20 m³ containers to a central non-ferrous-metal recovery plant operating on a private basis. Some of the industrial installations are now collecting these solutions themselves, rather than having the central treatment plant do so.

In future, some special solutions will be collected and stored for use in the Ruhrverband's treatment plants. Instead of buying expensive chemicals for phosphate precipitation, we are now using the iron-chloride concentrates from iron pickling plants, after equalizing the concentration and destroying the free hydrochloric acid by adding iron oxide from another central plant which operates on a private basis. This plant is recovering about 2 m³/h of hydrochloric acid by combusting the spent concentrates. This procedure agrees with the "Waste Recovery Program of the Federal Government of West Germany". Adequate storage capacity also makes continuous and stable treatment possible. We are able to accept all quantities of waste (from a beaker to a 20 m³ container), in all qualities (from concentrates, semi-concentrates, thin and dewatered sludges) at any time.

The pumps are another important consideration in the treatment plant. One should not try to find a pump material which will withstand all challenges. The pumps which can be repaired easily by replacing rotating parts and gaskets after having removed a few screws, and not after dismantling the whole plant, should be used. This also applies to the mixers.

The chemical treatment process must be automated to reduce the number of operators required and to obtain consistent results. A complete central plant which includes chemical treatment and disposal facility really requires only one man to operate it. However, a single man is not permitted to work alone in such a plant, so two men are required for each shift and back-ups are necessary in case of illness,

and during vacations. Our back-up operators are supplied from a nearby sewage treatment plant.

Protection from corrosion is another important consideration. Naturally, all storage tanks must be carefully sealed. Even neutralized sludges have a strong corrosive effect, because of their high salt concentrations. Hence the filter press plates should be coated by heating the cast iron plate and dipping it in a fluidized bed of special polymers. Plates manufactured from special plastic could also be used. The effluent from a central plant has salt concentrations of up to 5 g/l SO_4 , 1 g/l NO_3^- , and 5 G/l Cl^- . NO_2^- and 0, 2 g/l NH_4 may also be present. This effluent is, therefore, discharged to the inlet of the wastewater treatment plant, after passing through a final settling tank of long detention time. This treatment is necessary not only to oxidize ammonium and to reduce nitrates, but also to dilute the salts that are toxic to fish.

DISPOSAL, SUPERVISION OF THE DISPOSAL SITE, AND RECOVERY OF SPECIAL SLUDGES

The dewatered sludges from the central plant, as well as those from company-owned facilities are dumped at a disposal site. The disposal site usually includes lagoons for anaerobically digested municipal sludges and areas for dewatered hydroxide sludges. The bottom of the site is sealed with clay. Any percolating or surface water is withdrawn and returned to the central treatment plant. There is usually no surface water at all, and the percolating water contains only very small traces of metals, always below the standards required in Germany for waste disposal. (See Figures 6 and 7.)

The disposal sites should be surrounded by trees, or at least by bush, since wind erosion can cause problems.

Special sludges containing copper, nickel and zinc are being stored separate from the iron and chromium containing sludges (Figure 8). If the metal market allows, these sludges are given away for free, in order to save on disposal site space. Liquid and solid material wastes from the

	Standards when dis- charged to a river	Standard A115	Berlin	Frank- furt	Köln	Zürich
Sediment [ml/l]	0,3	*)	0,5	1	—	—
pH - value	6,5 - 9,0	6,5 - 9,5	6,5 - 8,0	6,0 - 9,0	6,0 - 9,0	6,5 - 9,0
Chromium [mg/l]	2,0	4,0	1,0	2,0	2,0	2,0
Copper [mg/l]	1,0	3,0	0,1	2,0	2,0	1,0
Nickel [mg/l]	3,0	5,0	1,0	2,0	3,0	2,0
Zinc [mg/l]	3,0	5,0	3,0	2,0	2,0	2,0
Cadmium [mg/l]	3,0	—	1,0	2,0	2,5	1,0
Iron [mg/l]	2,0	*)	—	20,0	5,0	—
Tin [mg/l]	—	—	5,0	—	2,0	2,0
CN decomposable [mg/l] by chlorine	0,1	1	0,1	frei 0,3 komplex 1,0	0,5	0,5
Free chlorine [mg/l]	—	—	—	1,0	—	0,5-3,0

*) Limits in dependence of the receiving treatment plant

Fig.6 Standard values for the toxicant content of waste waters when discharged into a sewerage system

	Dump Iserlohn	Dump Heiligenhaus
Sediment [mg/l]	0,1	0,1
pH - value [mg/l]	7,6	8,0
Copper [mg/l]	0,1	0,2
Zinc [mg/l]	0,1	1,3
Nickel [mg/l]	1,3	0,4
Chromium [mg/l]	0,1	0,1
Iron [mg/l]	0,7	0,9
Cyanide [mg/l]	0,1	0,1

Fig.7 Contamination of seepage from two centralized industrial sludge dumps

sludge sample	Cu	Zn	Fe	Cl	S	Ca O	Al ₂ O ₃	H ₂ O
1	3.35	2.85	0.09	0.17	15.4	29.5	0.15	50
2	11.4	4.7	0.02	0.62	11.9	22.5	0.15	50

Fig. 8 Analysis of Sludges for Recycling

electro-plating, and brass and copper pickling industries are recycled to save on operating costs, capacity and volume, not to make a profit.

The Ruhrverband collects about 10,000 t/year hydrochloric acid (containing 130 g Fe/l and 5 g free HCl/l), and 20,000 t/year $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ from iron pickling wastes. This represents a real economic factor as a raw material for the chemical industry. However, the sale of these products covers only the transportation costs, although we also save by not having to pay for neutralization, desludging, dewatering and dumping.

OTHER WASTES THAT CAN BE ACCEPTED

CN^- and NO_2^- salts from hardening furnaces are collected in containers at the industrial plants and sent to a central collection site, from which they are taken to an old salt-mine and disposed underground. All solid toxic materials are also handled in this way.

Water from cooling baths is occasionally brought to the central treatment plant at Iserlohn. Chemicals from laboratories and from the army (sodium hydroxide, calcium hypochlorite, etc.) are also accepted at the plant. As long as the capacity of our central plant is not exhausted, we accept these materials from all over Northrhine-Westfalia, and even from other parts of Germany.

A bulletin published through the "German Recovery Program" lists various installations which accept special wastes, liquids or solids, toxic or inert, organic or inorganic. In 1980 the first central recycling plant will be completed and will accept all types of waste from garbage to automobiles. This plant will produce paper, glass, metals, plastic materials, rubber, heat from the incinerator, and waste products for disposal.

ACCEPTANCE OF CENTRALIZED TREATMENT CONCEPTS IN OTHER COUNTRIES

Several projects for centralized treatment plants are being developed outside of Germany, for example, in Norway, Denmark and Switzerland. However, none of these has yet passed the planning stages.

Many central facilities for special wastes from various industries are operating successfully in Germany. We have found such facilities to be the best solution to the problem of pollution control in a country that has limited resources of land, air and water, and which is densely populated like ours.

ECONOMICS OF IN-PLANT TREATMENT VERSUS SHIPPING TO A CENTRAL PLANT

The decision as to whether it is more economic to treat wastes in an in-house facility or to transport them to a central facility requires careful investigation. The present situation, and possibilities of future development must be examined in each case, and the following items should be taken into account:

- 1) Cost of in-plant changes.
- 2) Cost of pretreatment up to desludging (3% DS).
- 3) Cost of further thickening and dewatering.
- 4) Cost of transporting and disposing of the filter cake.

If points 1) and 2) are considered in conjunction with the quantity of rinse water required, it is found that, below a certain volume of rinse water, it is more economic to use a central facility (Figures 13 and 14). Beyond this volume, it is cheaper to use an in-house facility. Naturally there is also a zone of uncertainty where it is impossible to determine which is most economical.

Thin sludges and filter cakes must be considered in the same manner, in order to decide whether to handle them directly or ship them to a central treatment plant.

Figures 9, 10, 11 and 12 have been prepared using our data for interest and repayment, operating time, annual depreciation, transportation distances, benefits for government, and savings on the cost of fresh water and sewerage for the municipal treatment plant and associations such as Ruhr River Association and the Ruhr Reservoir Association.

Now let me show you the example Dr. Buffa has seen himself. A galvanizing plant, which required 100 m³ of fresh water per day redesigned its entire processing line and improved the waste treatment sections for each processing unit (Figure 13).

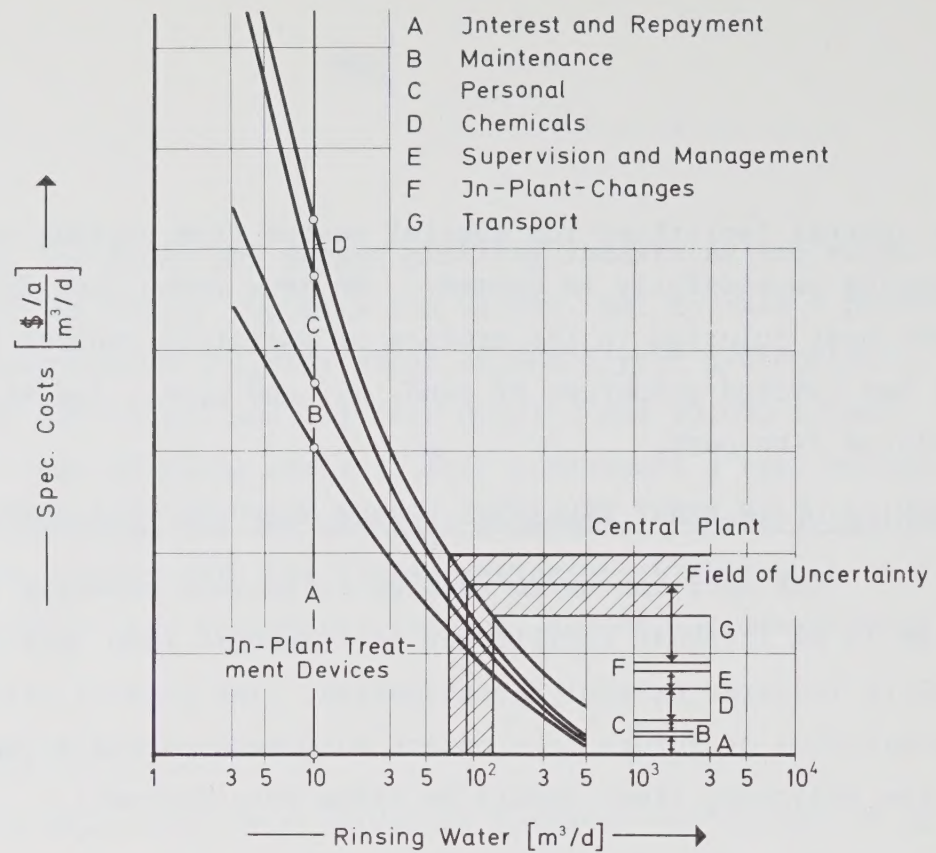


Fig. 9 Specific Annual Costs of Water Treatment with Jn-Plant and Central Stations in Dependence of Rinsing-Water Quantity (without Dewatering and Disposal of Sludges)

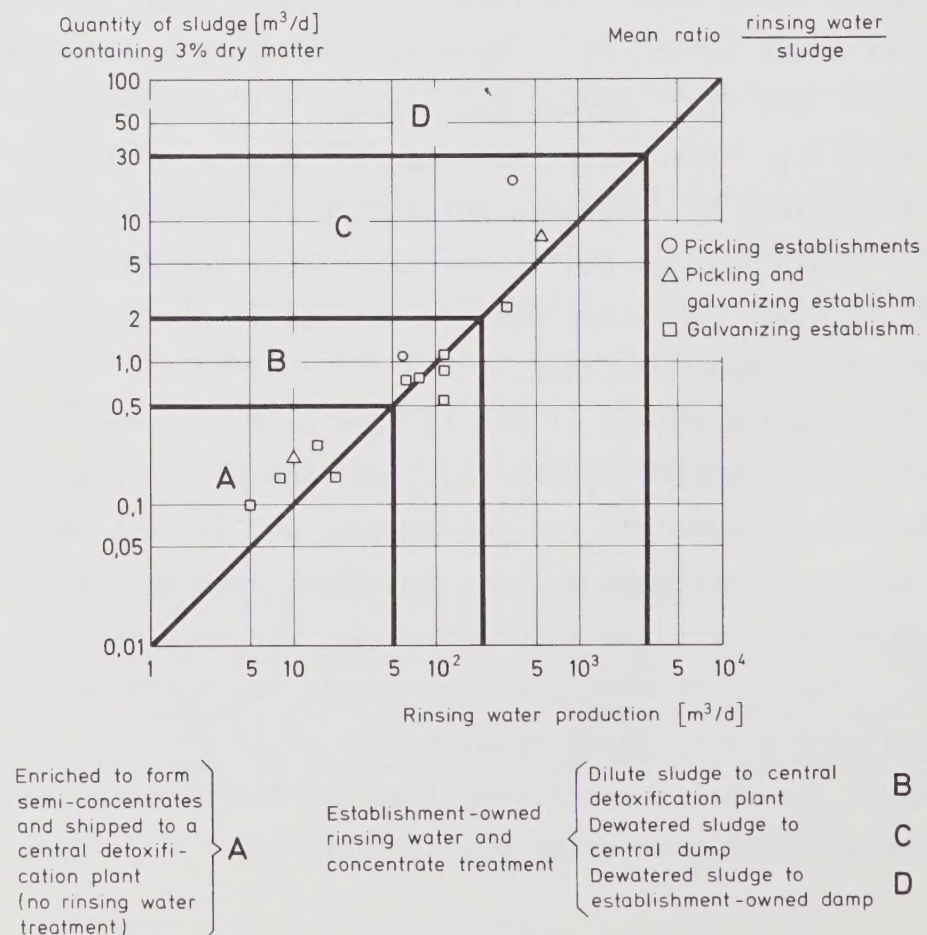


Fig. 10 Organization of toxicant removal, subject to the quantity of rinsing water

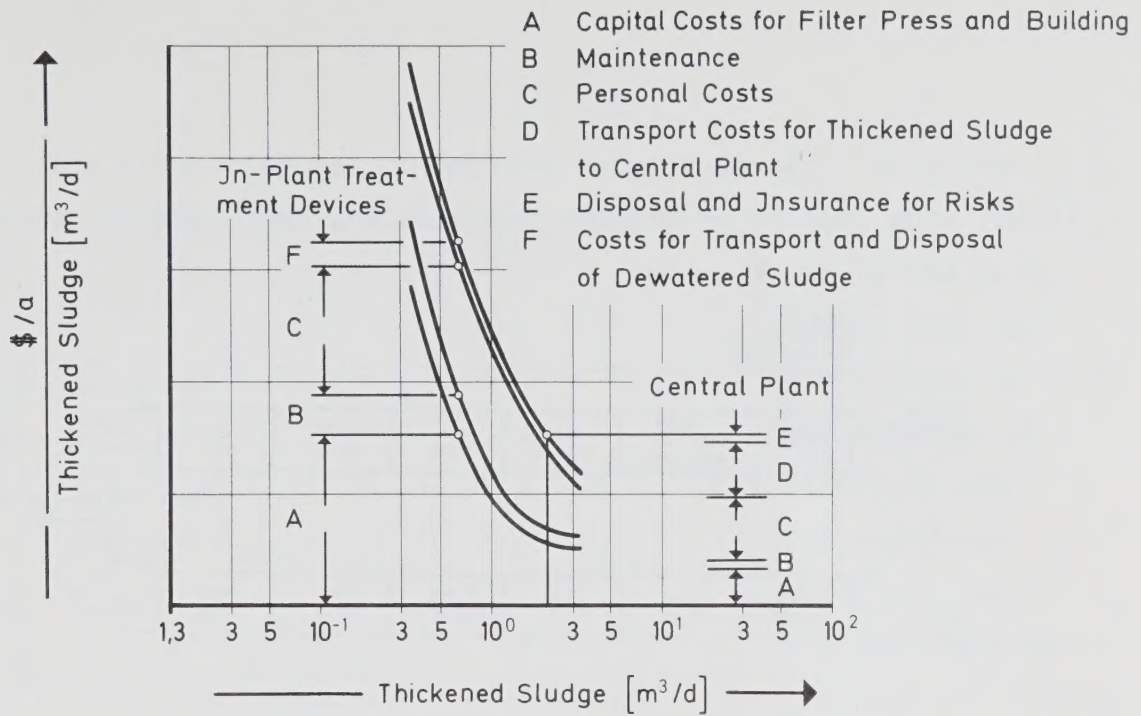


Fig. 11

Specific Costs of In-Plant and Central Sludge Dewatering Devices

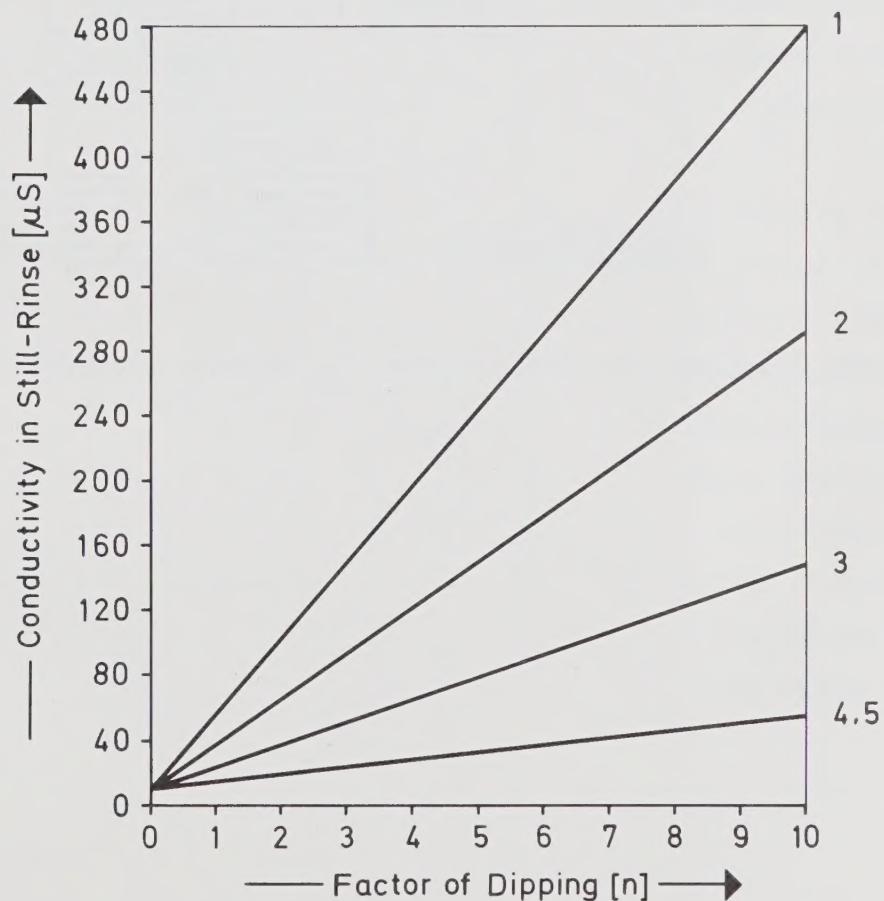


Fig. 12 Bath - Losses in Dependence of the Quality of Material - Removal from the Bath

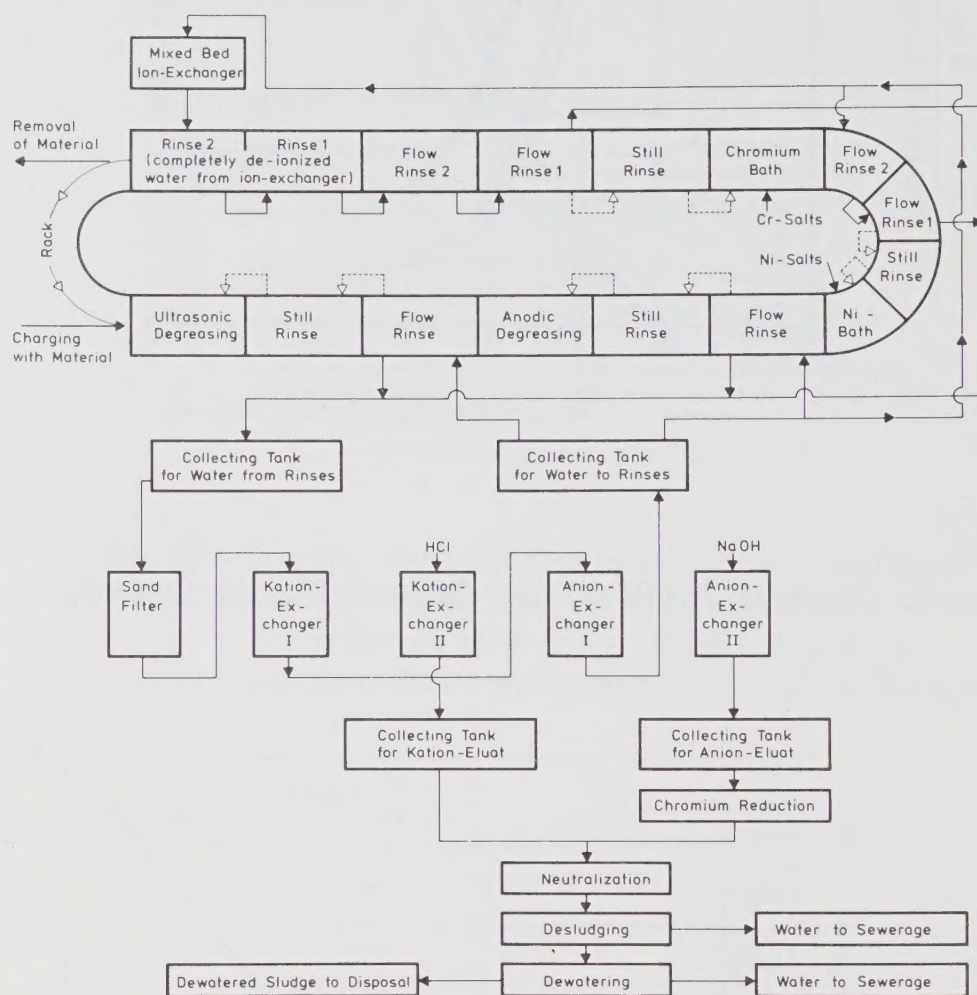


Fig.13 Schematic Flow - Sheet of a Modern Galvanizing Plant

ERRATA

p. 61 - Table 6.

Under the first column of values (United States):

Cd - Delete 0.1-0.4 (3)

Insert 0.1 (3)

Cr⁶ - Delete 0.05

Insert 0.1 (3)

Sn - Delete 1.0 (3)

Insert 1.0

Fluoride - Insert 5.0 (3)

Nitrites - Delete 5-15 (3)

p. 62 - Notes to Table 6.

Note # (1) - Reference should be (4) not (1).

p. 64 - Table 7.

The heading should read "UPPER TAME" not "UPPER THAME".

p. 66 - References.

Reference #4. should read:

Development Document for Effluent Limitations Guidelines and Standards of Performance - Metal Finishing Industry, prepared by Battelle's Columbus Laboratories for the United States Environmental Protection Agency - DRAFT subject to review, January, 1974.

The first step was to improve metal recovery. This means that copper, nickel, zinc and chromium containing liquors must remain either on the surface of the material to be finished or in the bath. How can this be done? If you pull the material out of the bath and take it directly to the rinse you remove, let us say, a maximum of 100% of the liquor. If you allow the piece to drip into the bath for 15 seconds, this value drops to about 60% and for 60 seconds, to 30%. By adding an electromagnetic vibrator with variable frequency and amplitude so that the best combination can be determined, you can minimize the bath losses to 10% by vibrating the rack while removing it from the bath. Ladling parts should be suspended so that the concentrates can flow out of the hollows. The rest can be blown out with air. Every percentage you save is your money, represented by the need for less metals or metal salts, less water for rinsing, and less wastewater to be handled. Even if water does not cost very much in Canada, and even if metals are cheaper here than in Germany, the law of Entropie still applies in both countries, i.e. you cannot protect your environment by wasting water and materials and you must concentrate the inevitable losses in as small a quantity of water as possible. Dilution will not keep your water clean.

The next step in good housekeeping is a good rinsing process with counter current water flow and replacement of the losses of the bath from the first still rinse. No matter which rinsing process you use, you will still be getting semi-concentrates, which can be handled as shown. The effluent from the flow rinse goes to the ion-exchanger and is then recirculated to the rinse. With two or three counter current flow rinses, the effluent from the second and third rinses can be sewered since the metal concentration will be under 5 mg/l, while the effluent from the first rinse after the bath represents semi-concentrates of about 95% of all metal losses. Many other variations of this operation are possible.

SUMMARY

In this paper I have attempted to outline the treatment being used for wastes from the metal finishing industry draining immediately or via sewers and treatment plants to the Ruhr River.

I hope that those who are struggling with the same problem will find this description useful.

PANEL DISCUSSION

Chairman: Mr. K. Coulter

Panelists: Mr. R.A. Abbott, Dr. L. Buffa, Dr. G. Mattock,
Mr. N. Roesler

QUESTION to Mr. Coulter:

Why is the accidental loss rate in Table 13 of your paper so high?

Mr. Coulter: The figures in Table 13 are the combined accident and deliberate dump losses. Many dumps take place out of necessity. The survey indicated deliberate dumps but not accidental dumps. The industry is aware of the possibility of losing as much as 2 to 3,000 gallons of concentrated solution by accident, frequently on weekends. Much of it can be avoided by good maintenance and good housekeeping practice. Losses in the quantities indicated are not just a Canadian problem but an international experience.

Dr. Silveston: On the last figures with circles around various centres indicating the number of establishments in each circle, I think the implication is that these would be likely sites for some centralized treatment plant. I want to point out that this is a very much oversimplified view of centralized treatment.

My group at the University of Waterloo has been interested in the problem of how one plans for centralized facilities. We have looked at the sludge treatment and disposal industry and what we find is that an extremely important factor in location is not where the sources are but where the disposal is going to be or how the material is to be eventually disposed of. If you are dealing with disposal by chemical recovery, you are dealing basically with a high capital investment industry, which then does justify a high degree of centralization and perhaps the type of geographical areas that you implied in your talk would apply. However, if you are talking strictly about disposal where you simply want to prevent pollution occurring from the material, this may be extremely misleading and what you may really want to do is to have a large number

of small simple treatment plants which would have low capital cost. Therefore, you would want to minimize the transport cost with a large number of small treatment plants widely dispersed through the area.

The whole area is a rather complicated one and I think one does a misservice to it by the type of figure you showed. It implies a conclusion which really isn't warranted.

Mr. Coulter: I think your comment is extremely good. Yes, it is simplified. There are many complications as seen in Mr. Roesler's presentation when he detailed the logistics, the psychological factors that are involved in persuading somebody to put a solution in the tank that says it is that solution. There are many complicated problems and that's our whole purpose today.

This was simply to indicate where in Canada the situation would have a possibility. It does not even suggest that anything less than 200 companies would be a justifiable situation.

There is no suggestion at all intended in this, other than to indicate where the concentration of this industry is in Canada.

Mr. Weber: United States experience with the metal finishing industry indicates that chemical consumption can usually be reduced except in the instance of acids. It is a serious problem where insufficient neutralizing material is available in the area.

QUESTION - Mr. G. Das, Environment Canada:

I see that there is a survey of the consumption of chemicals. Is there any survey of unaccounted for chemicals?

Mr. Coulter: Not in our survey. Most companies used purchasing records. The figures could reflect abnormally high buys to take advantage of low prices. On the other hand, they could have been reducing inventory during that year. We felt that there would be a reasonable balance between the two.

QUESTION:

What is the policy in the Ruhrverband with regard to membership? Do you seek an increase in membership? Do you limit growth? How do you decide on future members?

Mr. Roesler: The facilities are not limited to use by members only. A non-member does not pay for a share of the capital costs, but will pay a higher running cost. On the other hand, these facilities are all paid for so that we could equalize charges for the different substances. However, we don't do that, but present members have the priority if they wish to increase the amount delivered.

QUESTION:

How close are you to the limit in the quantities you can accept?

Mr. Roesler: We have no limitations. We are taking all material from the entire catchment area, even from other parts of Germany, but we only take it from elsewhere if our plant is not overloaded. We do not wish to increase the salt content of the river, but on the other hand, we want to run our plant most economically.

QUESTION:

In the original establishment of the centralized treatment system, did the suggestion come from government or did it come from government pressure?

Mr. Roesler: The initiative came from the Ruhrverband, out of necessity. For instance, the sewage treatment plant of Iserlohn showed concentrations of chromates up to 1,300 mg/l and cyanides up to 400 mg/l in the influent. These concentrations jumped significantly on weekends. We had, for instance, 2,000 mg/l of cadmium when one plant released 1.5 tons of cadmium. This is why we had to initiate these facilities.

QUESTION:

Did you approach private people to set these facilities up before you decided to do it yourself?

Mr. Roesler: No. We had the first central treatment facility, but when we wanted to get rid of some special material using recovery or recycle, a private company proposed handling the material if the quantity could be guaranteed on a weekly or monthly basis.

QUESTION:

How do you let new companies know that your facility is available?

Mr. Roesler: We are so well known, everyone is aware of our services. Even material not usually accepted by us can be disposed of, on occasion, through a catalogue called "The Chemical Exchange". You can find there people who are looking for certain materials and others who are offering materials, specifying quantity, concentration, purity and location. The German recovery philosophy tries to make an economic plus out of waste.

QUESTION:

Does a company near a borderline between central treatment plants have a choice as to which one he uses?

Mr. Roesler: Yes, he has the choice. He must only prove that he has followed the law.

QUESTION:

Do you require people sending you waste to give you advance warning?

Mr. Roesler: The law requires every cartage firm to keep a record of what he transports, when and where he delivered it, so that all waste materials can be accounted for. Previously, there were occasions when a cartage company would indicate he would dispose of material properly, but then simply dumped it in a sewer.

QUESTION:

Do you check the incoming material to see that it is what the person sending it says it is?

Mr. Roesler: This is a very big problem. The smallest error that is made is to send material called concentrate that is only half concentrate, but we also have received material called acidic which, in fact, contained cyanide. When this was stored with acidic material, we simply had to run.

Similarly, we have received pickling waste from a stainless steel pickling plant with high nitric acid content. When this was stored, therefore, in the wrong way, we could only run.

In another German facility, they received what was supposed to be cyanide hardening salts but, in fact, it contained some mustard gas. Some operators became ill and had to be hospitalized. You must expect this to happen, but it is better to have it at one point instead of 1,000 points.

QUESTION:

How long does it take to teach a new associate to label his wastes properly?

Mr. Roesler: About 6-12 months. We know now who consistently labels materials wrongly. 95% do not cause any problem; the remaining 5% will do it in spite of everything, including extra charges.

QUESTION:

Do you determine what you are receiving on a laboratory basis?

Mr. Roesler: Not on a laboratory basis, but we do spot check for cyanide.

QUESTION:

What percent of waste material can be recovered?

Mr. Roesler: At one time we recovered between 2-5%, but now it is less because in some instances the companies can send such material to a private company, specializing in concentrating and recovery. The originator may save up to 50 D.M. when compared to sending a waste directly to us.

QUESTION:

Would you like to express an opinion as to the possibility of centralized treatment in some of the areas of Canada?

Mr. Roesler: I would prefer not to answer the question since it would be your money that would be spent.

QUESTION to Dr. Mattock:

Are there other facilities you are aware of where similar centralized facilities are in use?

Dr. Mattock: Yes, there are other places which are organized on a slightly different basis which accept all wastes from a particular industry or wastes from a range of industries. I know of one in Switzerland and there are two operating in England. A third one is operating in England on a slightly more selective basis. These have evolved from being collection places for merely dumping into being full treatment operations which accept wastes of virtually any kind, provided they are classified so they can be treated properly.

QUESTION to Mr. Roesler:

Do you accept any solid metal wastes such as would be found in dust collectors where metal polishing is performed?

Mr. Roesler: No, we don't accept any solid metals, nor do we accept concentrated cyanide salts used for hardening. These are sent outside our area. We knew that there were great quantities of cyanide hardening salts being disposed of illegally. We did not want to deal with them at our centre so we have them containerised and dispose of them in an old salt mine.

QUESTION:

Would someone comment on the recovery of metals even though uneconomical as an option to land disposal? For instance, you did not make any money on the copper hydroxide you shipped to Canada?

Mr. Roesler: We didn't make any money, we only reduced our operating cost. That was our only intent. We saved disposal volume. It was more an environmental protection decision than an economic one.

QUESTION:

What is the area served by Iserlohn in square kilometers?

Mr. Roesler: 380 - 400 square kilometers. The number of metal finishing industries in this area number about 200 including plating, anodising, electroplating, rolling mills, etc.

QUESTION:

Do you have any current plans for new plants in the Ruhrverband area?

Mr. Roesler: No, not any at this time. We are trying to make full use of the existing facilities. We try to handle all materials.

We have tried to spread out our loading to other centralized treatment plants to reduce our salt load to the river. Similarly, we have tried to have them take some organic materials that are only 50% biodegradable since the remaining load must go to the river but this arrangement is no longer politically acceptable.

Mr. Coulter: I would like to comment on one reason why I feel centralized treatment works. Mr. Roesler mentioned that beside the central treatment plant there is a municipal sewage treatment plant. In our discussion yesterday, we discussed the effect of heavy metals and cyanide on sewage treatment plants. Mr. Abbott mentioned that the ability of the plant to accept these loads depended on the efficiency of the plant. Thus, in setting standards for sewage plants, the authorities must set them rigidly enough so that no matter what the operating conditions of the sewage plant are, it won't be upset by the metal or cyanide loads.

Having the two plants side by side, with one man in charge of both, they may be able to deliver higher than average loads from the centralized treatment plant on any given day while on other occasions the reverse may be required. It can be a day by day decision, so the loadings Mr. Roesler indicated, while acceptable normally, could be exceeded on some occasions. This contributes considerably to easing the combined costs of those two operations. Would Mr. Roesler like to comment further?

Mr. Roesler: I agree.

QUESTION to Dr. Buffa:

What do Canadian cost projections look like, compared to West German costs?

Dr. Buffa: We showed yesterday our estimates for individual treatment plants for both capital and operating costs. We showed them in relation to both sales and the number of employees. We estimated the cost of those individual treatment plants based on data from existing plant operations as of 1973.

We estimated that in the Maritimes, where no facilities exist, it would take \$50,000 to provide equipment. In Quebec, we estimated \$200-250,000 already in place and that \$2-3,000,000 would be needed in the future. In Ontario we estimated \$2.5 to 3,000,000 already in place with \$12-14,000,000 required in capital expenditures.

There were no appreciable treatment facilities in place in the rest of Canada with \$0.5 million to \$1.5 million likely to be required. That wasn't too serious but what was frightening was the annual operation cost:

Maritimes	-	\$30-40,000
Quebec	-	\$1.5-2.0 million
Ontario	-	\$8-10 million
Remaining	-	Up to \$1 million

While these are projections, we believe we are within a reasonable range.

Mr. Roesler: Our operating costs for one year are one million D. Marks.

Dr. Buffa: Just imagine \$400,000 to serve 200 metal finishing plants. In the Province of Ontario alone, with about the same number of plants, we are projecting up to \$10,000,000 per year. We hope that this will make you think of centralized treatment not only as a wish but as a viable economic solution for the industry.

We don't have any figures on the cost of central facilities in Canada.

Mr. Duyck: Could you give the figures for the capital cost of the German plant?

Mr. Roesler: The total capital cost of Iserlohn including the expansion, the new dumping site and the new filter press, was 2 million D. Marks, about \$800,000.

Mr. Sabanski, Tricil: We have estimated costs for destruction of cyanide, based on present volume we are receiving now, at \$1.00/lb, and for chromium \$1.10 to \$1.60. These astronomical costs are due to the present low volume. As the volume goes up, presumably the costs will go down.

Mr. Duyck: Did you have to invest in the cost of a trucking fleet?

Mr. Roesler: No, not at all. These are private fleets. There are about ten private trucking companies handling these materials. Contracts are let annually on a competitive basis.

Dr. Buffa: Would Mr. Roesler expand on the handling of the waste products? Your slides showed small containers being handled but I have seen larger containers. Would Mr. Roesler enlarge on the labelling of drums, maximum size of plastic drums which you handle and how they are handled and distributed?

Mr. Roesler: The maximum volume of a drum which can be handled is 800-1000 litres. The next size is 5 cu m. This is not a drum but rather a truck with a rubber lined container. In effect the smallest container is 60 litres. Two hundred litres is difficult to handle by hand so that it is usual for the company to put the 200 litre containers up to ten on a truck and ship to us. We will pump directly from the containers to our storage facility and the truck will return with the empties.

QUESTION:

Do you do a cleaning operation on the containers?

Mr. Roesler: No, normally not. Sometimes we get oil rubbish and all kinds of junk. But they only do it once. If our pumps are damaged, they have to pay for them. They get charges also for any special cleaning. We have rejected material that doesn't meet our rules.

Mr. Sabanski: Mr. Roesler, may I ask you about the recycling of sludges from your operation. You have indicated that some metal sludges are recycled. Can you go into more detail? Are they recycled as hydroxides or are they processed into the metal form?

Mr. Roesler: In the one case I mentioned earlier where the sludges were mixed with the metallic powder, the receiving refinery roasted them together with ore to recover the metal.

When they are sent to the private company I mentioned, the sludge is redissolved in waste acid to obtain a high concentration of

nickel, zinc and copper which is again precipitated. Now without the high concentration of calcium sulphite it is redissolved. This solution is then treated electrolytically to recover the metals.

Mr. Sabanski: Do you keep your metal bearing waste separate according to the various metals?

Mr. Roesler: No, we have them all mixed together.

Mr. Sabanski: How do you control prices?

Mr. Roesler: The control is done by the associates. They tell us we must keep our prices as low as possible consistent with keeping our reserves. On the other hand, they do not want to have to put up capital for expansion so we are allowed to build up a special fund for this purpose or for maintenance.

We have not raised the price for ten years. In fact, we lowered it after the first two years of operation. During this ten year period, we had a rise in wages of 100% and of chemicals of 50%. However, we don't believe we can maintain these prices in the future and will likely have higher prices.

Mr. Sabanski: Illegal dumping by carriers as you mentioned earlier is also very prevalent here due to a lack of control. Can you elaborate a little on how you control where your wastes go?

Mr. Roesler: Every associate must tell the Ruhrverband how much of each chemical he is buying, his water consumption, how many employees he has, etc. From these factors, he is charged for his membership.

We can ask him how he handles the rest of his material not brought to us. For example, nickel recovery in-plant in the newest factories is as high as 95%. This is not true in older facilities. We ask him, what have you done with the rest of your material - 30% in old plants; 5% in new plants? They can then produce their records and we can calculate if all materials are accounted for. If he ships some of his waste elsewhere, he must keep records to prove where he disposed of it and how much was there. We can then confirm this with the cartage company who must also keep records.

QUESTION - Mr. R. Demers, Environment Canada:

The central facility concept is very appealing and I find no fault with the technical reasoning. But what worries me the most is the operating mechanism. I assume you rely heavily on municipal regulations. How are these enforced and what kind of monitoring takes place?

Mr. Roesler: We have municipal regulations which prescribe what may be delivered to the sewage system and what may not. For example, the regulations specify pH: the effluent must be only 6.5 to 8.5. Sometimes we permit higher pH (9.5) because it helps precipitate metals in the primary treatment stage, thus saving us chemicals. The combined pH at the sewage plant will be about 8.

Dry solids are allowed up to 0.3 mg/l when discharging to a sewer but is zero when discharging to a river or water body. This would require a polishing filter and sometimes also other materials such as polyelectrolytes and chemicals such as calcium chloride to break down metal polyphosphates.

Mr. Demers: How are these regulations verified or checked?

Mr. Roesler: You must assume that 1% will not obey laws. Those who don't obey are the municipally run facilities such as the slaughter houses. Only after many fines do they respond and stop discharging materials such as blood. 1% of our associates cause 90% of our problems.

Mr. Coulter: How do you track down someone you suspect is breaking the law?

Mr. Roesler: We put them on a one-week check for 24 hours a day.

Mr. Demers: Who does that?

Mr. Roesler: He is our associate and he employs me so I cannot force him. We try to accomplish it by persuasion. It is sometimes very difficult. We depend on co-operation.

I have a paper here on how we disposed of copper nickel zinc hydroxide sludges to a fertiliser manufacturer who used them in small quantity to provide trace elements in fertiliser. The quantities were in the 100 ton a year category.

Mr. Sabanski: What is the degree of expertise of your operators?

Mr. Roesler: We have two workers who were trained on the job for six months. For special problems the Ruhrverband has a laboratory of 60 employees to deal with them. These problems are very rare.

The central facility is supervised by and controlled by our own laboratory and here is an analysis of one of our effluents:

Settleable Solids	-	0
pH	-	8.5
Total CN	-	0.19 mg/l
Oxid. CN	-	0.18 mg/l
Cu	-	12.0 mg/l
Ni	-	0.57 mg/l
Zn	-	0.8 mg/l
Cd	-	0.1 mg/l
Tot. Cr	-	0.32 mg/l
Hex. Cr	-	0.00 mg/l
Fe	-	2.6 mg/l
NH ₃	-	176 mg/l
Nitrates	-	680 mg/l
Nitrites	-	32 mg/l

But keep in mind that the influent is always in concentrations of grams/l; the effluent, of course, is in mg/l.

The ammonium content explains the high copper content since they form a complex which is hard to destroy. To reduce the copper levels more would require an ion exchanger which would cost in the millions of D. Marks. We permit the sewage treatment plant to remove this copper content and its effluent has zero copper content. The nitrites also are picked up by the sewage treatment plant. What does not disappear are the chlorides and sulphates. They are up to 5 g/l in each case in effluent from the sewage plant. The above values are only one example. Sometimes the copper is zero and sometimes twenty.

QUESTION to Mr. Roesler - Mr. Golomb, Ontario Research Foundation:

You indicated that you have a cyanide oxidation system in your plant but that you have cyanide hardening salts sent to an old salt mine for disposal. Is there not a danger of the cyanide being leached out of these dumps and into the underground water system? Why do you not oxidise them to prevent this risk?

Mr. Roesler: If we were to take these salts (about 80 tons per year) in our catchment area into our facility, we would have to enlarge our CN oxidising system ten times. That is not all, however. We could and have done it, but a large quantity of salts would result, including strontium sulphate, strontium carbonate, barium chloride. Barium can be precipitated easily but there remains about 40% including nitrates and nitrites and they are the problem. There is a chemical possibility but not an economic possibility of destroying them. It isn't even possible to destroy these quantities in a biological treatment plant. That is why we chose to dispose of them in the mines. Perhaps in 10-20 years they may become a resource but not at this time.

Mr. Duyck: We understand that you are frequently discharging 12 mg/l copper to the sewage treatment plant. We are told we cannot discharge more than 2 mg/l without endangering the biological treatment plant. What happens in your case? Do you have different bacteria?

Mr. Roesler: We are compromising. Normally we don't accept more than 2 mg/l direct discharge from a company to a sewage system. But, the quantity of water from the central treatment plant is small in comparison to the total influent to the sewage treatment plant.

The copper quantity is very low after mixing. The central plant discharge of 2 l/sec is mixed with a 100 l/sec so that the copper load to the sewage plant is very low. We are not happy with it nevertheless.

Mr. Coulter: That emphasizes the point I made earlier that having the plants side by side under one direction is a great convenience.

QUESTION - Dr. Silveston:

What disposal facilities are there existing now in Canada that will handle anyone's waste?

Mr. Abbott: The simple answer for Ontario is that there is nothing similar to that which Mr. Roesler has described.

Mr. Coulter: What currently is happening to sludges from waste treatment in Ontario?

Mr. Abbott: They are predominantly being trucked to municipal or industrial land fill sites.

Mr. Coulter: What do you anticipate as far as these public sites are concerned?

Mr. Abbott: I believe disposal to municipal land fill sites will be more and more restricted.

Mr. Roesler: It is just the same in Germany.

QUESTION - Dr. Silveston to Dr. Buffa:

The government announced some time ago a demonstration program called DPAT. It would seem that program might include funding or partial funding for such a plant as a demonstration for the country.

Dr. Buffa: Yes you are right. DPAT exists and in the last eight months I have seen, for a technical opinion, several proposals for some kind of centralized facility, collection facility, or treatment facility. Unfortunately, each one of those proposals was directed to a particular waste which the person proposing felt was viable from a recovery point of view. In other words, I would see a repeat of the same story that I understand happened in Sweden where some centralized facility would accept only the kind of waste they could use to make a profit. It would not accept any other kind of waste.

As a consequence, having been exposed to that situation indirectly, I convinced myself that approval for any of these proposals should be given only when a company proposes something which will accept all kinds of metal finishing wastes. That kind of proposal has not come forward yet. I am looking forward to it. That doesn't mean it is going to be approved but will receive very strong support. That will happen the first time as a demonstration, but the second and third time it will be different.

Dr. Silveston: My understanding of DPAT is that it is not restricted to just a commercial organization but it would apply to collective organizations such as an association, the metal finishers' association or even a municipality. Now, am I correct in that? DPAT's actual terms of reference are quite broad in the sense of organizations participating.

Mr. K. Bragg, Environment Canada: DPAT is designed to provide a maximum of 50% funding so any organization, however it is composed, would have to be able to generate half the funding. When you get into a municipal area DPAT might not be applicable in that all programs relating to municipal treatment would first go through Central Mortgage and Housing to see if their programs apply and if not, DPAT perhaps would apply. The only thing DPAT specifically excludes is the fundamental research work. It is a demonstration program for bigger projects.

QUESTION - Dr. Silveston to Mr. Roesler:

You referred from time to time to policy coming down from a board of directors. Who sits on this board?

Mr. Roesler: The board of directors of The Ruhr Reservoir Association is made up of directors of the different water works plus the mayors of various municipalities. The board of directors of the Ruhrverband consists of some of the directors of the waterworks, of industry representatives and the municipalities, about 30% each. Each of these groups pay about 1/3 of the total operating cost.

There is no board of directors of the central facility. The committee that decides on expenditures consists of myself representing the Ruhrverband, two from industry, one for the members and two for the non-members, two are from the municipality of Iserlohn, one man from the county and one from chamber of commerce, who meet once per year.

QUESTION - Dr. Buffa to Mr. Roesler:

I would like to know how charges are made to users and what kind of paper work is involved?

Mr. Roesler: Every associate gets a book, like a cheque book, with three copies. One stays with him, one goes to the central facility, the last goes to file. Now the German recovery program has resulted in a new book

which has six copies. It details the kind of waste, the code, the weight, the factory number, the number of the carrier and the destination number. From this we can follow every kilogram of waste material.

QUESTION - to Mr. Abbott - Mr. Penn, National Standard Company:

We have for disposal pickle liquors, rinse waters and cyanide waste. I am particularly interested in disposal of iron hydroxides, mixed with small amounts of other metal hydroxides. These must be disposed of as dried or semi-dried sludge. My understanding is that municipal disposal sites will be taking this kind of material provided it is dry enough. Is that correct?

Mr. Abbott: That is correct on the understanding that the site is licenced under the Environmental Protection Act waste management regulation.

Mr. Penn: The danger seems to be that the decomposition of organic materials will produce acids which will leach. Does this mean that this waste should not be mixed with regular municipal garbage?

Mr. Abbott: That is not a question I have the expertise to answer. The potential problem is under investigation. It is one of the concerns of control agencies. This concern has partly arisen out of the Canada-U.S. Agreement on Great Lakes Water Quality, where there is an expression of concern by both governments with respect to the impact of land use activities on Great Lakes Water Quality. One of the aspects of that concern is the investigation of the impact of land disposal of industrial sludges. The feeling is that municipal land disposal sites will be less and less available for the disposal of industrial sludges. The number in Ontario is declining now.

Mr. Penn: Iron hydroxides can be used for treatment procedures in municipal treatment plants for phosphate removal. Is the Ontario Government doing anything to encourage the greater use of them to help industry dispose of their problem?

Mr. Abbott: The Ministry is not discouraging the use of waste iron salts. The acceptance of that process is based on an evaluation at the treatment facility. The municipality will make its choice on whichever is the cheapest.

Mr. Penn: I have heard rumours that Toronto is using waste material from the U.S. It seems we are importing other people's pollution problem.

Mr. Abbott: I don't know about that, but we in Ontario are shipping a lot of material to the U.S. for disposal.

Mr. Penn: Since the quantities of iron hydroxides are high compared to other more valuable metal hydroxides, is it worth my while to dig a hole and bury my waste until it has some value - perhaps in 10-15 years?

Mr. Abbott: You may have no alternative.

QUESTION to Mr. Roesler - Mr. Penn:

Mr. Roesler: We saw a pile of iron hydroxide sludge being covered. Can you return it to agricultural use or build on it?

Mr. Roesler: No, you can make a meadow out of it. We leave it for two or three years and then growth will begin. If it is necessary to do it sooner, we accept material from land excavations. Natural growth occurs faster than by artificial planting.

CONCLUDING REMARKS by Dr. Buffa:

Yesterday morning, we had a quick glimpse into the future requirements for the Canadian metal finishing industry. You heard about the effectiveness and the limitations of municipal treatment plants in removing waste from metal finishing effluents. Yesterday afternoon, you heard about the recovery and re-use of metals from this industry - a charming, competent and stimulating presentation. We heard a clear invitation to consider centralized treatment as an intelligent, viable economical solution to disposal of metal finishing waste.

Today, we heard not only a good technical presentation, but also we heard something more. We heard someone speaking of water not as we normally speak of wastewater as something dirty that should go into the St. Lawrence as quickly as possible, but as a valuable commodity that also happens to contain some chemicals. When you have such a valuable thing, you try to remove the chemicals and re-use the water. It is a new concept to us and you have to go to Europe to be exposed to it.

In particular, I wish to thank the speakers for their contribution to this technology transfer seminar and I would like to thank both

Dr. Mattock and Mr. Roesler for kindly making their time available to us, without any compensation.

I am confident that this seminar has answered the questions you may have had about centralized treatment. I am pleased with the proceedings and hope you are as well.

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